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ERRATA.

Page 20, 2d line of foot-note, for cellular, etc., *read* cellular or, etc.
" 24, line 16, for represent, *read* present.
" 24, lines 3 and 10 from bottom, for Cacteria, *read* bacteria.
" 62, line 31, for nassiform, *read* napiforn.
" 62, line 33, for -petaled, *read* -petioled.
" 80, line 8 from bottom, for 1860, *read* 1869.
" 205, lines 6 and 7, the proportion of nitre referred to is that of *fused* nitre.
" 227, line 17 from bottom, for two, *read* ten.

THE

AMERICAN

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[THIRD SERIES.]

ART. I.—*On some phenomena of Binocular Vision;** by JOSEPH LECONTE, Prof. of Geol. and Nat. Hist., Univ. of California.

V. *Stereoscopic phenomena.*

IT is a familiar fact that in stereoscopic pictures, properly mounted, identical points in the foregrounds of the two pictures are always a little nearer together than identical points in the backgrounds. With a pair of compasses we can, by this means, easily test whether or not pictures are properly mounted. It is evident therefore that it requires greater optic convergence to unite the foregrounds than the backgrounds of the two pictures. It is also evident that we cannot at the same time and with the same convergence unite all parts of the pictures. When objects in the foreground are united, objects in the background are seen double, the images being *homonymous;* when objects in the background are united, then objects in the foreground are seen double, the images being *heteronymous*; when objects in the middle ground are united, then both fore and background are doubled but in different directions. In looking at pictures in a stereoscope, therefore, the eyes range rapidly from fore to background and *vice versa*, uniting the objects successively, and finding the visual phenomena precisely similar in all respects to natural vision of near and distant objects, instinctively introduces the idea of depth of space. Or even looking *steadily* at any point, say in the middle ground, the depth of space is still perceived, as in nature under similar circumstances, and for the same reason, viz: that the *eye or the mind, instinc-*

* For the preceding articles on this subject, see II, xlvii, 68, 153, and III, 1, 33.

tively distinguishes between homonymous and heteronymous imag referring the one to a position *beyond*, and the other to a positi *on this side* the point of sight.

This last point is so important in the theory of binocul perspective, and so at variance with the accepted view on th subject that I must dwell upon it a moment. It is now gene ally admitted that Wheatstone's idea of *a complete mental co bination of dissimilar pictures or images is not true*, either stereoscopic experiments or in natural vision;* but the theo which has displaced Wheatstone's, and which is now general held, though certainly true, is, I believe, still *imperfect.* Accor ing to Brücke, Brewster, Prevost and others, the highest a thorities on this subject, binocular perspective is *wholly* t result of rapid changes of convergence, or what I have call ranging of the eyes back and forth from foreground to bac ground and *vice versa.*† I think, however, close attention our visual perceptions will confirm the popular notion th *we distinctly perceive depth of space or the relative distance of* *jects while gazing steadily at one point*, even in those cases which we are unassisted in our judgment by any other form perspective. This is accounted for on the principle just a nounced, viz: that the eye instinctively distinguishes betwe homonymous and heteronymous images, referring the former objects *beyond* and the latter to objects *on this side* the point sight, or in other words, each eye knows its own images. It true we are not usually *conscious* of making this distinctio but the same is true of the rapid changes of convergence an many other visual phenomena upon which judgments are base The observation of Dove mentioned by Claparède‡ that stere scopic relief is distinctly perceived by *the light of an electr spark*, and the undeniable fact that such relief is distinctl perceived by *the light of a flash of lightning*, cannot be explain by the usual theory. According to Wheatstone's well-know experiments in 1835, the duration of an electric spark from Leyden jar is $\frac{1}{24000}$ (·000042) of a second.§ The later expe

* Mr. Townes in the elaborate paper "on the physiology of vision" alrea alluded to in my last paper, (III, 1, 33,) devotes much time and many experime to the subversion of this view, under the impression that it is still the universal accepted view.

† See an admirable review of the whole subject by Claparède, Bib. Un Archives des Sci. Nouv. Per., vol iii, p. 138 and seq.

‡ Ibid. p. 155.

§ I give Wheatstone's result on the authority of De la Rive, (vol. ii, p. 18 trans.) and of Daguin (vol. iii, p. 518, trans.). It is somewhat remarkable th nearly all writers on physics give Wheatstone's result as a little less th $\frac{1}{1000000}$ instead of $\frac{1}{24000}$ of a second. Prof. Rood in his recent admira researches on this subject has unfortunately fallen into the same mistake. T $\frac{1}{1000000}$ of a second does indeed occur in Wheatstone's paper, but it is the ti occupied by the electric current in passing from one interruption of the wire

ments of Fedderson in 1858, and of Prof. O. N. Rood in 1869, give nearly the same results; the former ·00004 of a second, and the latter from ·000022 to ·000050* depending upon the degree of the charge and the length of the spark. The duration of a flash of lightning, according to Rood,† is about $\frac{1}{500}$ of a second. Now it is obviously impossible that in $\frac{1}{25000}$ or even in $\frac{1}{500}$ of a second the eye can change its convergence so as to adapt it consecutively to single visions of different objects at different distances. The perception of stereoscopic relief under these circumstances is therefore inexplicable on any other theory than that which I propose. The *true theory* of binocular perspective seems, therefore, to be this: *the eye, even when fixed steadily on one point, perceives the relative distance of objects by means of double images, as already explained; but this perception is made much clearer by the ranging of the eyes back and forth, uniting successively the images of near and distant objects.*

If the pictures on a stereoscopic card be *reversed*, i. e. the right picture placed on the left side and the left picture on the right side, *the binocular perspective is also reversed*, the objects in the foregrounds being seen at a distance, and objects in the backgrounds near at hand; in other words, the foregrounds of the pictures become the background of the scene, and the backgrounds of the pictures the foreground of the scene. The reason is obvious. By changing the pictures, identical points in the backgrounds become nearer together than those of the foregrounds. Thus greater optic convergence is necessary now to combine objects in the backgrounds of the pictures than in the foregrounds, and therefore by the principles of binocular perspective the former will appear nearer than the latter. These facts are illustrated in figs. 1 and 2, in which *S S* is the septum of the stereoscope, *r S* the right and *l S* the left picture, R and L the right and left eye, N the nose, a*a* identical points in the foregrounds, b*b*‡ identical points in the backgrounds of the right and left pictures respectively, and A and B the places behind, where a*a* and b*b* are seen. Fig. 1 represents the result where the pictures are properly mounted, and fig. 2 when reversed. By comparing the two figures the reverse perspective and its cause becomes evident.

This inverse perspective was long ago pointed out and explained by Wheatstone, and stereoscopic pictures are often made expressly to exhibit it. I am not aware, however, that any one has drawn attention to the beautiful, and in some respects

another—*the time between the occurrence of the sparks and not the duration* of the sparks; it is measured by the *arc of displacement* of the image of middle spark, not by the *arc of elongation* of the images of the sparks. I am indebted to my brother Prof. John Le Conte for having directed my attention to this mistake.

* This Jour., II, vol. xlviii, p. 153. † This Jour., III, vol. i, p. 15.

‡ The italic *a* and *b* are *underlined* in the figures.

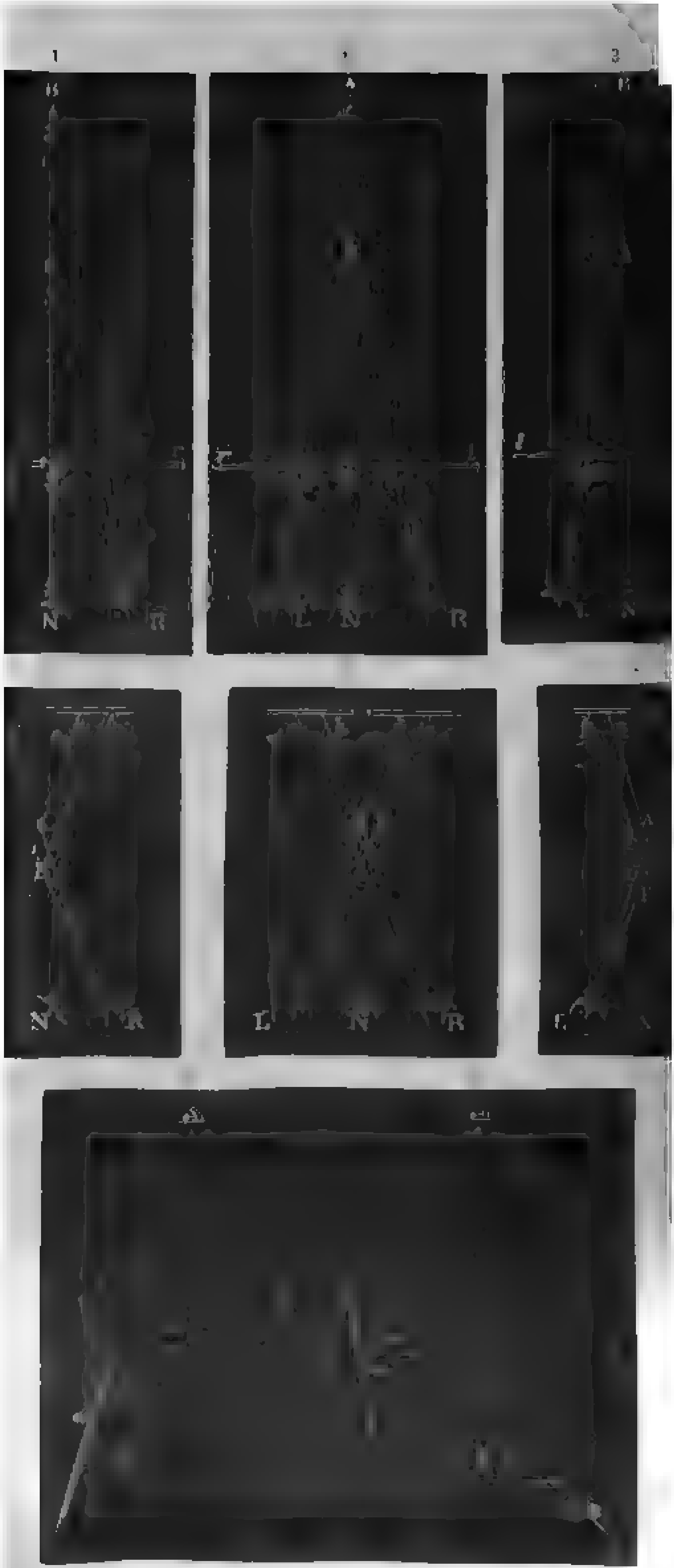
peculiar, results both of natural and inverse perspective, produced by the combination of stereoscopic pictures with *the naked eye* by *squinting.* I find that I am able to combine stereoscopic pictures in this way, quite as easily or even more easily than with the stereoscope. The results by this mode of combination differ from ordinary stereoscopic results in several respects. 1st. In combining on *this side* the plane of the pictures by squinting the *right-eye* image of the *left* picture, combines with the *left-eye* image of the *right* picture; while in combining *beyond* the plane of the pictures as in ordinary stereoscopic experiments, it is the right-eye image of the *right* picture, and the left-eye image of the *left* picture which combine to form the binocular result. This is evident on comparing fig. 1 with fig. 3. 2d. Besides the binocular result there are of course homonymous monocular pictures on the right and left; while in the stereoscope these monocular pictures (which, however, in this case would be heteronymous) are cut off by the septum. 3d. The binocular result, instead of being magnified as in the stereoscope, is seen in exquisite miniature and has all the charm of miniature pictures. 4th. The depth of perspective is proportionally less than in combination beyond the card. 5th. The perspective is always the *reverse* of that given by the stereoscope, and therefore, in order to produce the same perspective the *mounting* must be reversed.

If ordinary stereoscopic photographs be reversed and the pictures be then combined *with the naked eye* by squinting, the stereoscopic effect is as perfect as can be imagined. Miniature houses, gardens, lawns, statuettes, fountains, &c., such as Gulliver might have seen in the land of Lilliput, are presented *in perfect perspective.* I have often amused myself by changing the mounting of stereoscopic pictures in order to enjoy the exquisite effect. Of course in order that there should be perfect definition of the objects, there must be complete dissociation of the focal and axial adjustments, as already explained in my first paper.* If stereoscopic pictures are combined by squinting *without reversing the mounting*, then of course the *perspective is reversed.* These facts are represented by figs. 3 and 4. Fig. 3 represents the combination of fore and background when the mounting is suitable for the stereoscope. By comparing this with fig. 1, the reversal of the perspective is obvious. Fig. 4, represents the combination of fore and background when the mounting is changed. It will be observed that the perspective is true.

In combining with the naked eye stereoscopic pictures mounted in the usual way, it is not always easy, sometimes it

* This Jour., II, vol. xlvii, p. 68.

is not possible, to bring out the inverse perspective distinctly. The reason is that it violates other kinds of perspective, and sometimes sets at defiance the known properties of bodies. It is most distinct when other kinds of perspective are least distinct. In natural vision there are many kinds of perspective, or many modes of judging of the relative distance of objects; viz. *aerial* perspective or increasing dimness with increasing distance; *mathematical* perspective or decreasing size with increasing distance; change of focal adjustment necessary for *distinct* vision of near and distant objects; change of axial adjustment necessary for *single vision* of near and distant objects. The first three of these are *monocular*, the last is *binocular*. The painter can give only the first two. The stereoscope gives also the last, and its surprising effects are due to this cause. In natural vision alone all kinds concur. Now in reversing the binocular perspective we do not affect the other kinds. There is therefore, a discordance between this and the other kinds, and when they exist it must overpower them. This it cannot do when the mathematical perspective is strongly marked. Thus the curious effects of inverse perspective is best seen when the other forms of perspective, particularly the mathematical, are least marked. It is impossible to see it in cases of long buildings or long rows of buildings taken in perspective. In such cases the mathematical overpowers the binocular perspective. But in buildings and grounds seen directly in front it is very evident. I now combine with the naked eye stereoscopic photographs, taken directly in front, of a building, the profile outline of which is given in fig. 5; as soon as by rectification of the focal adjustment the image becomes clear, the inverse perspective comes out distinctly as represented in fig. 6. The roofs *a a* and the lawn *b* slope away downward as if we were looking at them from beneath. They are transparent, however, for the grass on the lawn stands upright. The column *c* is seen beyond the house as if through a transparency or as if the wall of the building was wanting in that part. I now try a scene in Lombardy taken on glass. Viewed in the stereoscope a village is seen in the distance and a row of poplars far in front with their straight trunks projected against the houses of the village; combined by squinting the *village* is seen *in front* and the *trees* through the houses far *in the distance*. Next I try stereoscopic pictures of the full moon. In the stereoscope it is egg-shaped with the end of the egg toward the observer; combined with the naked eye, it is a *shallow concave* very perfect and beautiful. In a picture of Paris viewed in the same way, the mathematical perspective is entirely overpowered by the binocular perspective, and the city is seen sloping away downwards as if seen from beneath through a transparent ground, but with the smaller



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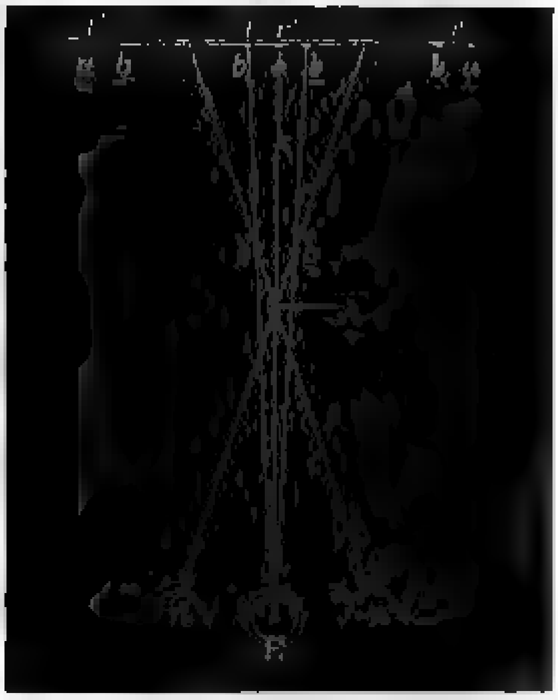
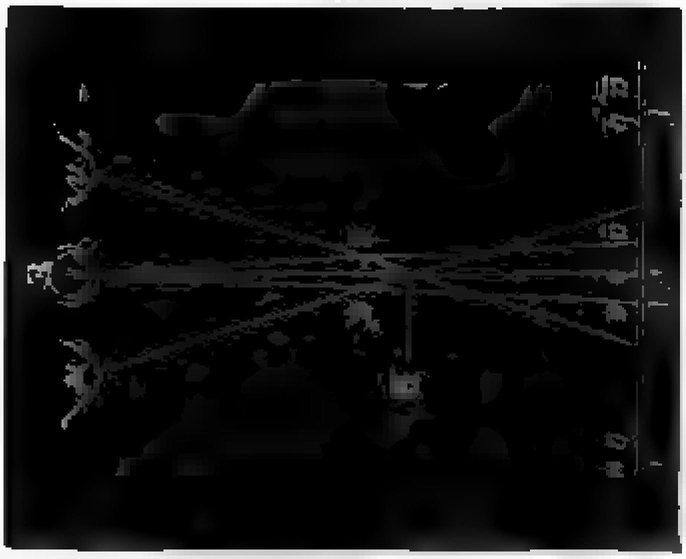
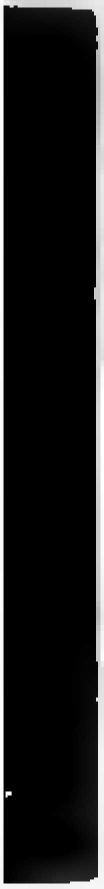
11.







houses above and nearer, and the larger farther away in the distance.

On combining in a similar manner one of those skeleton polyhedra so frequently used to illustrate stereoscopic principles, I find the stereoscopic effect equally perfect as with the stereoscope except that the nearer triangular face is *smaller* than the farther one instead of the contrary. Nothing can exhibit more clearly than these experiments, the entire distinctness of the binocular from every other kind of perspective.

Stereoscopic pictures may be combined with the naked eye, *also beyond* the plane of the card in the manner of a stereoscope; but there are two difficulties in the way of success in this kind of combination. In the first place in most stereoscopic pictures, identical points are farther apart than the eyes, and therefore, cannot be combined beyond the pictures without the aid of lenses or prisms. In the second place, even if the pictures are not farther apart than the eyes, and may therefore be thus combined, the dissociation of the focal from the axial adjustment, as already explained in my first paper* is difficult and imperfect, and the combined picture therefore is not clear.

I wish now to apply the method proposed in my last article, in the representation of stereoscopic phenomena. The usual method, which I have used in figs. 1, 2, 3, and 4, because it is familiar, represents perfectly the position of objects seen *single* and therefore their relative distance or the depth of space, when the eyes are directed upon them consecutively; but cannot represent the position of *double images* in the stereoscope any more than it can in natural vision. Fig. 7, gives the mode of representing by the usual method. A R, A L is the position of the optic axes when objects a *a* in the foregrounds are combined at A and b*b*′† the position of the double images of b*b*, seen at the same distance as A; B R, B L the direction of the optic axes when objects b*b* in the backgrounds are combined and seen at B and a*a*′, the apparent position of a*a* at the same distance as B. Fig. 8 gives the same when pictures are combined by squinting.

Now it is evident that this mode of representation is not true, for we *do not* refer b*b*′ to the same distance as A, when we look at A, nor a*a*′ to the same distance as B when we look at B. The whole stereoscopic effect would be lost if we did. On the other hand my method of representation gives the true apparent positions of the double images as we now proceed to show.

When we gaze through a stereoscope the two pictures seem to slide inward over each other until they unite to form a single

* This Jour., II, xlvii, pp. 73 and 76.

† As in my previous article dashed letters mean *left-eye* images.

ure in the middle. The septum of the stereoscope is there- doubled heteronymously, and forms two parallel planes or ls bounding the field of view on either side. Between these bounding planes, the eye (combined eyes) from its apparent tral position seems to look straight forward upon the scene. soon as we converge the eyes upon any object in the scene, two septa or bounding planes seem to converge to the same ree, and if produced would meet at the point of sight, if be in the median line, or in any case at the *distance* of the ıt of sight. As the point of sight however, is always far ond the septa, practically the septa will seem nearly or quite allel. Fig. 9 gives the actual relation of parts and the ition of the visual lines when b*b* objects in the backgrounds the pictures are united and seen at B; fig. 10 gives the ıal result. The two pictures are slid over each other each a f interocular space until b*b* fig. 9, unites in the middle g. 10, and a*a* slide by each other and become heteronymous. e combined picture *b* is seen at B (fig. 10), because we are scious of an optic convergence suitable for that distance, or other words we are conscious of *looking* at that distance. In s mode of representation the position of B, when it is on the dian line, is determined by the intersection of the double ta or median lines $n\ S$, $n'\ S'$ produced; and the position of of the scene is determined by the intersection of the lines m the eye through *aa* of the card (ray lines), with the dian lines $n\ S$, $n'\ S'$. It will be observed that these double ıges occupy precisely the position of those of an object at fig. 9. Fig. 11, gives the relation of parts and the direction the optic axes, when objects a*a* in the foregrounds of the tures are combined and seen at A, and fig. 12, the visual ult. To combine a*a* (fig. 11). b*b* do not slide by each other, l are therefore homonymous, and are therefore referred be- ıd A and seen at b*b'* (fig. 12) precisely as if they were the ıble images of an object situated at B (fig. 11). In the re- sentation (fig. 12) the exact position of b*b'* of the scene, is ermined as before by the intersection of median lines with *ray lines.*

The phenomena of combination by squinting is represented figs. 13, 14, 15, of which fig. 13 represents the actual relation parts, and the direction of the optic axes when foregrounds [backgrounds of the pictures *r* and *l* are consecutively ıbined. In this case the mounting is supposed to be changed s to make the perspective natural. Fig. 14 represents the ıal result when the foregrounds are united, and fig. 15, ın the backgrounds are united. The positions of the ıble images in the scene are determined as before. In the e of combination by *squinting*, the two images of the card not slide over each other *inward*, as in the stereoscope, but

outward; so that, as already stated, the *right-eye* image of the *left* picture covers the left-eye image of the *right* picture, to form the binocular picture or scene; while homonymous images of the right and left pictures are seen to the right and left. I have represented this in figs. 14 and 15, where r and l are right and left pictures as seen by the right eye, and r' l' the same as seen by the left eye. By careful inspection, after what I have already said, the figures will explain themselves. It is true, this mode of representation is complex, and, for those unaccustomed to binocular experiments, perhaps difficult to understand; but it has the advantage of truly representing the somewhat complex visual phenomena.

Oakland, Cal., March 20, 1871.

ART. II.—*On three Masses of Meteoric Iron, from Augusta Co., Virginia*; by J. W. MALLET, Professor of Anal. and Applied Chemistry, University of Virginia.

NEARLY two years ago I learned that a lump of iron, which from the description given of it I supposed to be meteoric, had been turned up by the plough in Augusta Co. in this State, and soon afterwards I obtained possession of this specimen by the kind assistance of Hon. J. B. Baldwin of Staunton. It proved to be beyond question a meteorite, weighing about 56 lbs.

A few months later, I saw at the Annual Fair of the State Agricultural Society in Richmond, a second mass, of smaller size, weighing about 36 lbs., which had come from the same county, and was exhibited along with some iron ores by Maj. Jed. Hotchkiss of Staunton. Learning from me that I was about to examine and analyze my own specimen, and was anxious to compare it with the other found in the same part of the country, Maj. Hotchkiss was obliging enough to lend me the latter, and to permit me to cut off enough for analysis.

Quite recently he has placed in my hands a third specimen—also from Augusta Co.—weighing but about 3½ lbs.

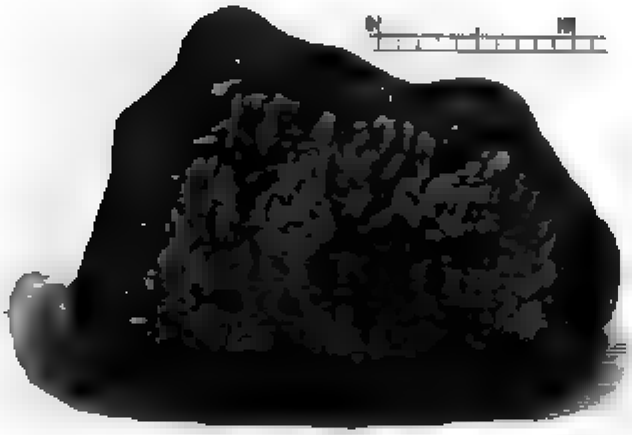
I shall speak of these three masses as No. 1, No. 2, and No. 3, in the order in which they are mentioned above; No. 1 being my own specimen, and Nos. 2 and 3 those of Maj. Hotchkiss.

All three present quite the same general appearance. They are of a very irregular pear shape, one end of each mass being larger and more rounded than the other—the smaller end of each is somewhat flattened, but by concave surfaces, in one direction. No. 1 was more massive and rounded than the

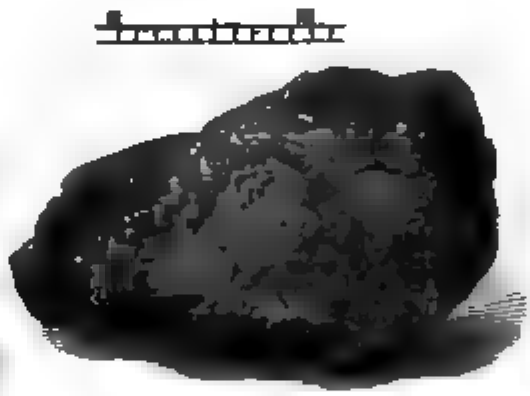
others—No. 2 most flattened—the latter had some rude resemblance in shape to a shoulder of mutton. The dimensions of the masses before cutting were as follows:

	No. 1.	No. 2.	No. 3.
Maximum length,	28 centimeters	27 c. m.	11 c. m.
" width, at large end,	21 "	10 "	9 "
" " at small end,	17 "	19 "	5 "
" thickness, at large end,	13 "	13 "	8 "
" " at small end,	11 "	5 "	3 "

No. 1.



No. 2.



No. 3.

A pretty good idea of the shape and size may be obtained from the accompanying figures, from photographs of the original specimens with attached scale. The exact weights before cutting were,

No. 1.	No. 2.	No. 3.
25,429 grams.	16,441 grams.	1,644 grams.

the masses being entire, nothing having been previously detached from any one of them.

The surface of each of the masses is rough and irregular. At some points, which have been rubbed, the iron exhibits its metallic luster, and traces of its crystalline character may be observed, but nearly the whole surface is covered with a dark brown crust, consisting essentially of hydrated ferric oxide, which varies from about an eighth to a third of an inch in thickness. This crust is hard, and pretty firmly adherent. On exposure to moist air a rusty liquid exudes in drops from numerous points upon the surface, and in this watery liquid chlorine, iron (chiefly as ferrous chloride), and nickel were detected. The masses are of course magnetic, and on examination give evidence of feeble magnetic polarity, with multiple poles.

The union of hardness and toughness in the iron makes it quite difficult to cut, and in attempting to obtain with the planing machine a slice of considerable size the ordinary cutting tools were blunted and broken; it was found necessary to drill a row of holes and connect these by a cut made with the planer.

The specific gravity was taken for Nos. 1 and 2 with solid pieces of about 140 grams and 95 grams, respectively, cut from the interior of the masses, and for No. 3 with about 10 grams of clean shavings (from the planer) in a specific gravity bottle. The results were,

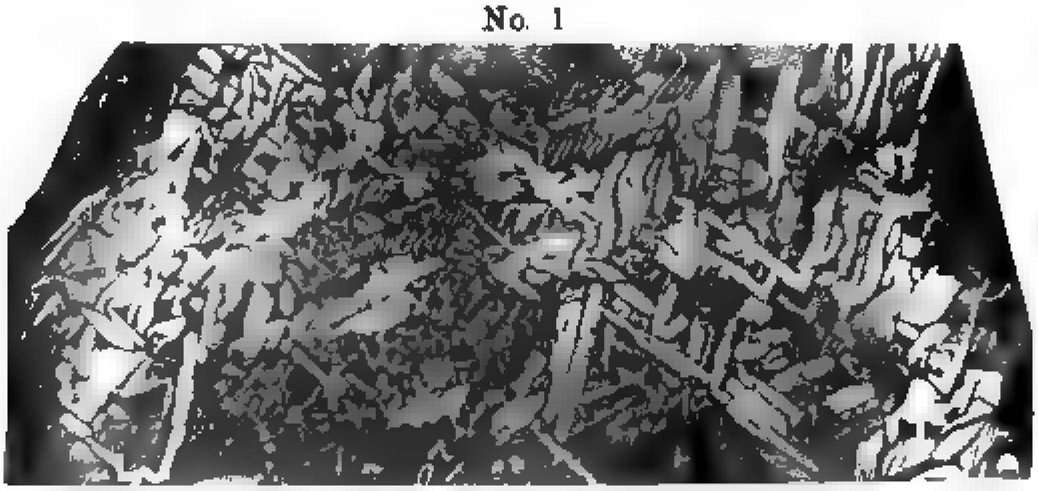
	No. 1.	No. 2.	No. 3.
Specific gravity, at 15° C.	7·853	7·855	7·839

The interior structure of the iron is compact and highly crystalline, of much the same general character throughout, but a few small grains and streaks of a brownish yellow mineral were noticed, which on being picked out and examined proved to be troilite. There are, however, minute fissures running through several portions of the metal.

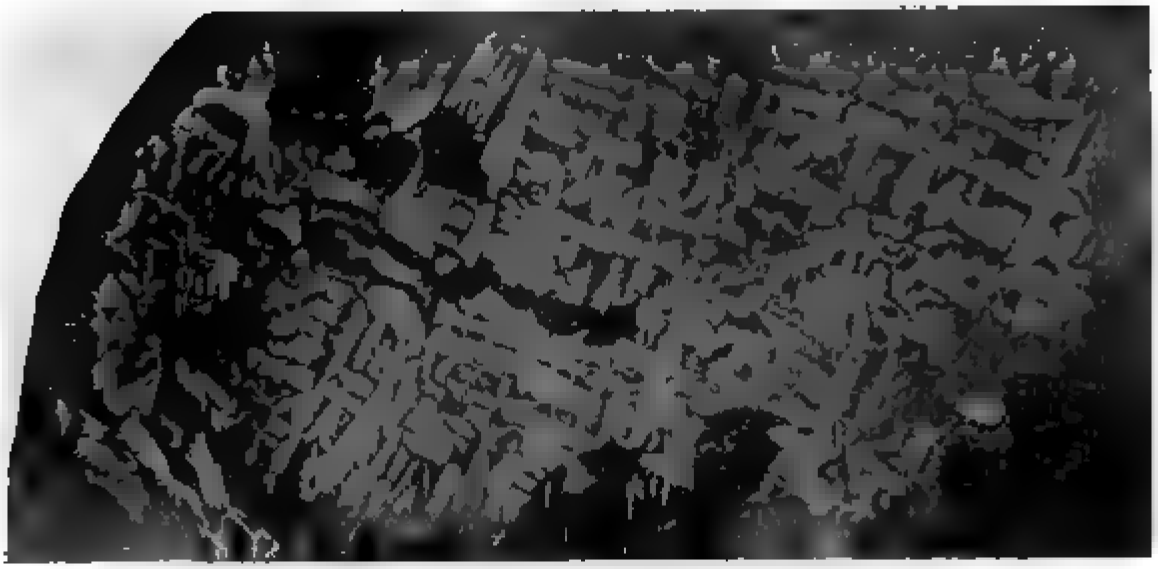
Traces of the Widmannstättian figures may be detected upon a polished surface even without the aid of an acid, and when the iron has been etched by nitric acid the markings are exceedingly distinct and beautiful, fully as much so as in any specimen of meteoric iron I have ever seen. The general appearance is a good deal like that of the iron from Lenarto in Hungary, and some of the Mexican specimens. In the mass No. 1, upon the principal cut surface, narrow, well-defined bands of alternate nickel-iron and Schreibersite are parallel or intersect each other at angles of about 60° and 120°; in the figures on the principal surface of No. 2, the angles of intersection more nearly approach 90°; on the much smaller cut surface of No. 3, the figures are somewhat more irregular, but the angles approach 60°. By etching surfaces obtained in other planes it was rendered evident that the difference of appearance is merely due to looking at different projections of the same crystalline structure. The accompanying engravings, taken from photographs, exhibit the results of etching these specimens.

The metal soon rusts upon cut surfaces, especially where the exudation of chlorine occurs, and this renders more distinctly visible the slight fissures which penetrate the interior.

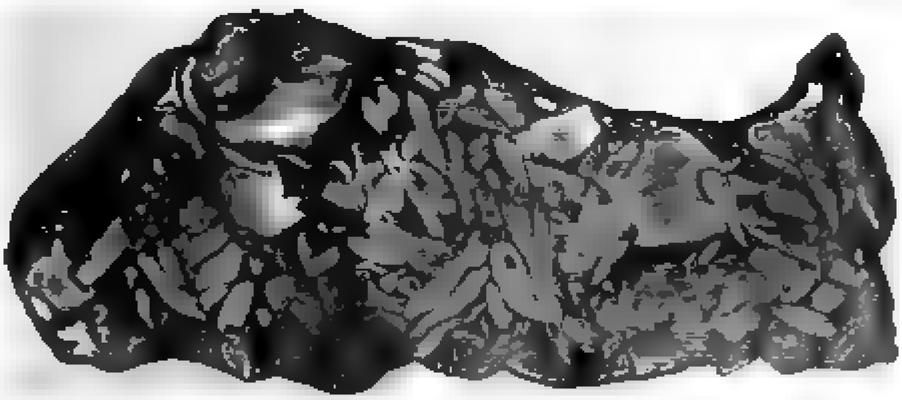
No. 1



No. 2.



No. 3.



The iron is not passive, though very easily rendered so by nitric acid. It reduces copper rather slowly from the sulphate, and if the whole surface be covered by the latter metal and then washed under a stream of water, rubbing hard with the hand or a cloth, a part of the copper comes off very easily, leaving the remainder firmly attached and reproducing very beautifully the Widmannstättian figures; obviously a case of galvanic deposition, the Schreibersite being the electro-negative solid and receiving the coating of copper.

By the prolonged action of acid delicate white laminæ of Schreibersite are brought into view, which if completely detached are found to be flexible and strongly magnetic.

The following are the results of chemical analysis.

	No. 1.	No. 2.	No. 3.
Iron,	88·706	88·365	89·007
Nickel,	10·163	10·242	9·964
Cobalt,	·396	·428	·387
Copper,	·003	·004	·003
Tin,	·002	·002	·003
Manganese,	trace	----	trace
Phosphorus,	·341	·362	·375
Sulphur,	·019	·008	·026
Chlorine,	·003	·002	·004

	No. 1.	No. 2.	No. 3.
Carbon,	·172	·185	·122
Silica,	·067	·061	·056
	99·872	99·659	99·947

These numbers are so closely accordant that there can be no doubt of the masses being essentially identical in chemical composition.

The nickel and iron were separated, in a cold and quite dilute solution, by means of carbonate of baryta, and the precipitates obtained were carefully tested as to purity before the weights were finally accepted as correct.

Considerable quantities of material were used for the determination of the minor constituents. Particular attention was given to the identification of the minute quantity of tin present, as Professor J. Lawrence Smith has lately mentioned* the fact, that he has never found this metal in the course of numerous analyses of meteoric iron. The precipitate with sulphuretted hydrogen, which contained the tin and copper, was in each case obtained from a solution of more than a hundred grams of the iron.

I feel satisfied that the chlorine is not of meteoric origin—not an essential constituent of the original masses—but has been derived from the soil in which the iron has lain imbedded. The exudation of watery drops containing metallic chlorides is observable only at points on the outside and on cut surfaces along the lines of fissures communicating with the outside. Although chlorine is mentioned above as found in the general analysis of the planing machine shavings, I failed altogether to detect it in a specially selected solid piece of some fifty grams taken from a part of No. 1 destitute of fissures or flaws.

The siliceous residue is set down as silicic acid, but some of it seems to have in reality existed as silicide of iron. A part of this residue having been examined with the blowpipe to identify it as silicic acid, another portion was looked at with a magnifying power of 250 to 500 diameters, and in polarized light was seen to consist of an amorphous powder, and rounded, transparent grains of very small dimensions, for the most part from ·0025 to ·0100 millimeter in diameter, of well-marked doubly refracting character.

It seems in the highest degree probable that these three masses of meteoric iron represent portions of a single fall from the heavens, agreeing so closely as they do in external character and appearance, in density and internal structure, and in chemical constitution ; having, moreover, all been found at but short distances from each other. The precise localities from which they came are as follows :

* This Journal, II, xlix, 333, (May, 1870).

No. 1, from a spot on the land of Mr. Robert Van Lear, about five miles (a little East of) North from Staunton, in 38° 14′ N. lat. and 79° 01′ W. long.

No. 2, from the land of Mr. M. Fackler, about one mile to the Southeast of the locality of No. 1.

No. 3, about half a mile still further Southeast, or rather a little North of a N.W. and S.E. line passing through the last named locality.

It will be interesting to watch for the possible detection of other masses in the same neighborhood.

This makes the fourth recorded instance of meteorites found within the State of Virginia, the three preceding having been,

1. Meteoric stone, which fell in Chesterfield Co., June 4th, 1828, (this Jour. I, xv, 195 and xvi, 191).

2. Meteoric iron, found in Grayson Co., described by Prof. Rogers of this University in 1842, (this Jour., I, xliii, 169).

3. Meteoric iron, found in Roanoke Co., and described by Prof. Rogers in 1842, (this Jour., I, xliii, 169).

University of Virginia, March 27, 1871.

ART. III.—*The Glacial Features of Green Bay of Lake Michigan, with some observations on a probable former outlet of Lake Superior;* by N. H. WINCHELL, of the Geological Corps of Michigan.

THE topographical features of the region of Green Bay, are strikingly dependent on the geological structure as acted on by glacial forces. The west coast is low, and in but few places can the underlying rock be seen above the drift deposits. The immediate shore varies but little from the regular trend of the outcropping Trenton limestone. But two considerable bends occur on the west coast; and they are caused by alluvial deposits at the mouths of the Peshtigo and Menominee rivers. Across these rivers the bearing of the Trenton limestone is disclosed in the rapids which occur a few miles above their mouths. At the mouth of Little Bay de Noc the course of the coast line takes a direction nearly N. and S., an interesting fact, the special significance of which will be noticed further on.

The east coast is in the same way dependent on the line of bearing of the Niagara limestone; but, very unlike the west coast, it is frequently indented by bays which by their great depth of water form beautiful ship harbors. Of these Sturgeon Bay is the most remarkable, and may be taken as a type of all the deep indentures occurring on the east shore of Green Bay. The vast escarpment of Niagara limestone rises sometimes

immediately from the water, but more frequently it passes a short distance from the shore, forming an almost continuous rock-barrier 150 to 200 feet in height from the head of Great Bay de Noc to near the south end of Green Bay. It also underlies the whole table-land of the peninsula which encloses Green Bay, and affords by its natural dip a gentle descent E.S.E. toward Lake Michigan. Hence the entire drainage of the peninsula is into that lake, the "divide" being along the shore of Green Bay. The east and west shores afford another noticeable contrast in the comparative depth of the off-shore water. By inspecting the charts of the U. S. Lake Survey the recorded soundings along the west side show very shoal water, while on the east side the "ten-fathom line" runs near the land, frequently uniting with the shore-line, the entrances to the little bays being uniformly very deep. The passage through Port des Morts is 21 fathoms, north of Louse island 24 fathoms. The mouth of Eagle harbor is 11 fathoms, of Ellison's bay 12 fathoms, and of Hedgehog harbor 17 fathoms. The average depth of Green Bay is 16 to 18 fathoms.

The uniformity in the direction of these bays is another remarkable fact. They indent the peninsula in a southerly or southeasterly direction. On the contrary the bays on the opposite side of the peninsula, and opening into Lake Michigan, have a very uniform direction northerly or northwesterly, complementing those opening into Green Bay in such a way, that the peninsula is in several cases almost intersected by their near inosculation.

The barrier of the Niagara limestone is broken through at each of these bays, and its broken off ends form perpendicular and bald bluffs which face each other across their entrances, and rise to the height of 75 to 175 feet. Government and Hibbard's bluffs enclose Sturgeon bay. The former has a height of 115 feet, the latter about 80 feet. Eagle Bluff is on the south side of Eagle harbor and has a height of 149 feet 10 inches. Its counterpart on the north side is about 60 feet. Garden Bay in Great bay de Noc is another example of the same phenomenon. The Niagara barrier is more broken down between Port des Morts and Pt. de Morts and Pt. de Tour than at any other place. Projecting southward, the peninsula which encloses Great bay de Noc and terminates with Pt. de Tour, is a counterpart of that which encloses Green Bay; and the whole interval between Door Bluff on the south and Sag Bluff in Great bay de Noc on the north, is but an enlarged illustration of the phenomena already described. In this case the Niagara limestone is so completely broken down as to admit the waters of Lake Michigan, the Potawatamie islands, which lie in that interval, being its only parts remaining above the level of the lake.

Glacial striæ and polished surfaces at the head of Green Bay ive a direction N. 34° E. coinciding with the axis of Green ay. In the bay north of Sag and Burnt Bluffs, in Great Bay Noc, they run about N.W. and S.E.

Among the glacial features may be mentioned the general pect of the east shore of Green Bay and of Great Bay de Noc. hose deeply cut bays before mentioned must be regarded as the nature of fiords, and doubtless owe their origin to spurs om the main glacier which excavated the Green Bay valley. he Sturgeon Bay spur was probably aided in taking its more sterly trend by a local glacier which contemporaneously deended the valley of the Uenominee. By their uniformity of rection a tendency is indicated in the main glacier to move a more southerly direction than the general direction of reen Bay requires. In fact the islands between Port des orts and Pt. de Tour exhibit the effect of intense glacier tion in a direction N. and S. Long trails of detritus from these lands shoal the water for several miles southward; but toward e north the water becomes suddenly very deep.

A natural result of this spurring off from the main glacier is hibited in the westward tendency of the coast line immeiately south of the bays thus formed. The diversion of at portion of the moving glacier which passed through the alley of Sturgeon Bay would allow the extension of the pposing barrier of the Niagara limestone farther toward the est, thus bringing into view lower formations (Clinton and incinnati); and the spur which excavated Eagle harbor, ted in the same way to permit the existence of the point ıst west from the harbor on which the Clinton limestone is gain exposed.

Another evidence of the more southward tendency of the ıain glacier consists in the fact that it actually broke through he Niagara barrier in numerous instances in a southerly direcion, but did not once encroach upon the Trenton, on the pposite side of Green Bay, although it hardly rises above he water level.

We may therefore regard the fact established that the local lacier which excavated the valley of Green Bay, as far south s to include lakes Winnebago and Horicon in Wisconsin, was leflected from its N. and S. course by the escarpment of the Niagara limestone; and we must infer that its greatest force was felt where it first encountered it. We see the escarpment nost demolished between Port des Morts and Pt. de Tour, and onclude that that interval must lie in the course of the original lacier. A course nothward thence carries us up the valley of Little Bay de Noc and the Whitefish river to the shore of Lake Superior. If we examine the south shore of Lake Superior,

we find that in a line directly north from the head of Little Bay de Noc occurs the only break in the otherwise continuous rock barrier. Dr. D. Houghton, in his report to the Michigan Legislature in 1840, says that "an elevated range of hills," or in another place, "an elevated and very regular chain of hills stretches from Point Iroquois to the Pictured Rocks," from which place they "pass away from the shore southwesterly," and Dr. Houghton adds that "the western prolongation of this rock has not been determined." From the mouth of the Chocolate river, six or eight miles east of Marquette, to a point one-and-a-half miles east of the mouth of Train river, the shore is low and occupied with drift deposits, the usual rocky barrier of sandstone is interrupted and entirely wanting. Both to the east and to the west from this interval the shore of the lake is formed by the rocky rampart either of the Lake Superior sandstone on the east, or of the Huronian and other Eozoic rocks on the west. Although this barrier passes a few miles away from the shore east of the Pictured Rocks it is nevertheless a continuous barrier of "sandstone hills" which cause the Falls of the Taquomenon, 90 feet in height, and appear in precipitous cliffs at or near Iroquois Point.

Again, from the mouth of Chocolate river to the falls of the upper Menominee occurs, in general, the strike of the Huronian, and from the latter place to the head of Keweenaw bay, a right line would pass some of the highest primary knobs and through the head waters of some of the principal rivers of the Upper Peninsula of Michigan. This rough and elevated character continues westward to the Montreal river, near the western extremity of Lake Superior. It is therefore rendered probable that the last lingering glacier, which was able to prolong itself beyond the south shore of Lake Superior, passed through the gap which occurs north from the head of Little Bay de Noc. It has been repeatedly stated by geologists who have observed the glacial striæ about Lake Superior, that their general direction is N.E. and S.W. It is therefore a fact of special significance, that the grooves at and near the mouth of Chocolate river show a north and south direction. At a point two miles west of the mouth of Carp river, and a few miles east of Marquette, there are two systems of glacial grooves, one running north 55° east, and the other north 5° east. Mr. Desor says of these: "The latter are distinctly seen crossing the others, and are therefore more recent. Some of them are besides distinctly curved, as if the body which produced them had been deflected in ascending the slope, a peculiarity not yet observed elsewhere." On an island east of Dead river (near Marquette) there are also two systems of furrows, one running N. and S. and one N. 20° E., the latter being the more distinct

and sometimes taking the form of troughs four feet wide and two feet deep.* These indicate that the continental glacier moved in a direction N.E. and S.W., forming the deepest furrows, but that the local glacier passed N. and S. It was also, doubtless, "deflected" from its course, and the opposition of the Huronian formation, which gives the coast great elevation and abruptly turns it north from this place, may be supposed to have caused that change in direction.

In relation to the country between the head of Little Bay de Noc and the shore of Lake Superior we may infer that a valley exists, or did exist when the glacial epoch was waning, connecting Lake Superior with Lake Michigan through Little Bay de Noc, and that the present outlet of Lake Superior is of comparatively recent date. Not only do the descriptions of this tract by Messrs. Foster and Whitney confirm that inference, but examinations made the present summer, by Mr. A. S. Wadsworth of the Michigan Geological Survey, almost directly demonstrate the former outlet of Lake Superior to have been through the Whitefish valley. There is a continuous valley with high drift banks uninterrupted, from the mouth of the Whitefish river to Lake Superior. Upon reaching the watershed which lies but little above Lake Superior and within twelve miles of the mouth of the Train river, the head waters of the two rivers interlock on an extensive flat and rocky bed from which the drift has been removed and piled up in continuous bluffs on either side. From the summit of these bluffs extend extensive "pine plains," toward the east and west. On this rocky bottom are traces of running water, spread over an area of many acres, consisting of the peculiar "pot holes," from which "many cords of rock" have been removed. There are also deep gorges and crevices worn smooth by the motion of water and drifting sand.

Thus it appears that not only was the outlet of Lake Superior through Little Bay de Noc up to the close of the Tertiary, but that it continued to exist there after the stratification of the drift. The curious excavation and piling up of the drift on either side of the Whitefish valley could only have been done since the deposit of the same, and the water-worn surface of the Trenton limestone, on the top of the water-shed, must have been produced since the dawn of the Terrace Epoch. The old Tertiary channel is still obscured by the drift, either to the east or west of the channel discovered by Mr. Wadsworth.

Ann Arbor, Mich., August 20, 1870.

* Foster and Whitney's Report on L. Superior, Part I, p. 205.

ART. IV.—*Infusorial Circuit of Generations;* by THEOD. C. HILGARD.

THE soft and "naked," transparent and really animal* forms here to be considered, have some very striking and peculiar features in common. Their bodies are delicate, transparent, gelatinous, granular, and evidently *sexless*, although studded with reproductive yolks and locomotive molecules of the most varied description. On contact with air, when drying up, they do not leave behind any coherent coat or tissue whatever; but so soon as they are affected by incipient exsiccation, at once, by some sudden internal commotion, as if *melting* away, they become *liquid*, and entirely dissolve into a "sauce" of quite uniform, hyaline molecules, about $\frac{1}{3000}$ line in diameter. They are all evidently *immature* forms, subject to a vast cycle of progressive and retrograde developments and infinitely multiplying the molecular germs at every individual dissolution.† A little salt, glycerine, or sugar destroys their present form; but they seem to be hardly affected by morphia or atropia, even in strong solutions.

It is this feature of the *non-endurance in drying up*, which renders it at once certain, that no such sarcode bodies can continue to exist *in integro*, when exposed to the full heat of summer, on a cracking dry tub, or on a roof, likewise as torrid as a blazing July sun can render it within four weeks. The same applies to all the confervaceous, palmellaceous, protococcous, desmidiaceous, etc., fresh-water spawns, of true Mosses; which, once collapsed by drought, rarely continue growth in a progressive sense. With the exception of their *common* "nostoc"-phase‡ (specially adapted to endure even excessive dryness) they

* i. e. exclusive of all the chlorophyll-endowed, silica-coated, and automatous, or cellular cell-like sarcodic bodies and also the clear and vibrionic forms which belong to the algoid *bryaceous developments*. They are partly classed as green "Infusoria," and also constitute the "Chlorospermeæ" of "Algæ."

† The same doubtless applies to a small "Stentor Roe," seen hovering up and down in water taken from ponds, aquaria, etc. It is of a hazy white color, scarcely perceptible to the naked eye, and remarkable for never touching the surface. When placed under the microscope, in a drop exposed to air, this animal germ (in shape resembling a Cyprea or a coffee bean) is seen violently throwing open its "cloak" or mantle, exhibiting an intense ciliary (*fingered*) vibratory action, *all over the interior surface*. It then throws out hyaline constitutive brood-balls of various sizes, *each endowed with the same "fingered" action*—(as if "kneaded about" in invisible hands)—and ultimately entirely *flows apart into such fleshy cilia*, only leaving the *intestine* behind.

‡ This form of self-multiplying, serial chorophyll bead-strings enveloped in a foliaceous slime is common to Lichens (particularly the genus Collema) and various brooding-phases of the algoid (*chlorospermous*) moss-spawns. With the Lichens, the internal chlorophyll of their thallus often develops, as is well known, in similar bead-strings, borne on the end of colorless (fungoid) tissue-fibers; in a manner also represented in the anatomy of *Blodgettia confervoides*, in Harvey's "Nereïs."

evive" *only* by starting anew from very reduced, but im-
nsely multitudinous *constituent particles of their own*, which
dure exsiccation. In the class of Fungi we meet with simi-
examples, as e. g. in the case of the yeast-plant, which can
lure a considerable degree of exsiccation without impairing
vitality of those cell-*contents*, which actually exercise the
mentive energies and also consume the old cell-coat—(*not* com-
n cellulose, by the way) in this process of reviving. Like-
e, the vermillion, gummose (*tubercularia*) pimples on rotting
ck Oak branches can endure a baking process in the burn-
sun, but still revive on contact with water. Its spicular
permatia" (*fusidium*, resembling Naviculæ or magnetic
dles) at once assume an oscillatory motion and swell up to
size of those didymous (*trichothecium*) spores which pres-
ly stand erect on pedicels, as a pink velvet, in the chinks
the bark and collapse at the first touch of the sun; while
ir ultimate subcortical development into a mature, "black
mel" Sphæria again perdures in the heat.

Under the circumstances above mentioned, the rain water
l dry dust carried by the wind to the roof, and thence col-
ted into a perfectly dry tub, itself standing on a similar roof,
hin a few days was found swarming with all the minor
ases of the Vorticello-planarian germ-developments. Both
bodies and the yolks or gemmæ of the latter occasionally
ome reduced, by spontaneous dissolution, into very minute
ticles, each in the *wet* state capable of resuming the regene-
ion of individual germs. Judging from analogy, it is but
sonable to suppose, that it is this reduced nubecular and
lecular condition, which adapts them to last and survive in
ry condition, as we find it not only with the Fungi, but also
the case of the pruinose-pulverulent, primitive moss-spawns,
three agreeing in this feature of being "reduced to dust,"
t of which they are again resuscitated. This evanescent con-
ion, however, where gelatinous particles of about $\frac{1}{2000}$ of a
e diameter shrink alike to imperceptible dimensions, affords
pretext whatever for assuming identities, just because we
rselves lose the *means of discrimination*. Whenever the iden-
y of *substance* is preserved, each of these various molecular
ganisms preserves its cyclar developments distinct from simi-
, corresponding ones as true species, so far as my observa-
ns go.

There being, at present, no comprehensive pictorial works
ailable to fall back upon for reference, that are sufficiently
rect, even in their designs, to identify the forms, allowance
ist be made for the liberties of comparison taken in the fol-
ving descriptive representation of the most frequent infusorial
cesses.

On extensive clay formations, all over the central part of the Mississippi valley, the first appearance, in the warm season, of vegetable life, e. g. in water-pools recently formed by rain, etc., is mainly that of "Chlamydococcus pluvialis," even where the clay is immediately taken from the deepest excavations. As the sequel of my papers will show, this particular form belongs to the common Silver-moss (*Bryum argenteum*) which is widely disseminated all over the surface of the globe, and that, by the way, rather scantily "fructifies" in a "sexual" fashion, i. e. by the development of a *theca;* but on clayey soils fills all the sluggish and stagnant waters with its virescent uliginous spawns; while it covers the surface of fields, by millions of acres, with a minute crust, or "*brick red leprosy*,"* whose fine, molecular dust is swept aloft by every wind. Immediately before the frost, the same fields are densely covered with a small crop of minute moss, doomed to perish in this form, but revived in its spawns at the first thaw in the shape of a universal *chalk-white* "*clay-bloom*," or pruinose efflorescence from the soil, and that in water at once re-develops into the so-called *Protococcus* (or *Chlamydococcus*) *pluvialis* in the form of green flagellate-roving beads.

These minute, but in this instance *coated*, swarming cells are replete with chlorophyll, and are globular ovoid in shape. They have at their smaller end, just where the motor *flagellum* (or vibratory lash) arises, a clear point of substance; wherein, in a small percentage of these cells, *a parasite* is found to develop.

This parasite is a perfectly colorless globule, apparent in the clear navel-point of the cell, and exhibits a faintly opalescent hue. As it grows, the cell which harbors the "*incubus*" loses its own individual vitality. It ceases to swarm about and dissect into living, chlorophylliferous and automatous progenies, as the live ones do. Instead of spontaneously dissolving as in the living process the cell-coat remains firm; and as the parasitic animal yolk grows and occupies more space, executing tremulous and vibratory contractions, the chlorophyll is pressed into the rear, a lifeless mass. At last the cell is ruptured in

* See St. Louis Med. Reporter, Jan. 1st, 1867, pp. 522, 527—528. Also Proc. St. Louis Ac. Sc. (July, 1861), vol. ii, No. 1, p. 160; and vol. i, p. 156. For "Chlorococcum" read "*Sphærocarpus*" (lately renamed "*Protuberans*" Ag.) and its "botrydium" progenies. The latter collapse and turn red. This pulverulent, *miniate* "*Lepraria kermesina*" Auct., must, however, by no means be confounded with the darkly purpureous, uliginous moss-spawns which cover, e. g. the hilly "Orange-sand" regions of the State of Mississippi. It is prevalent in winter in damp weather, and consists of matted red "Microcoleus" or lumbricoid (sheathing) moss-cells, each one containing a central brood-fiber which is medullary-dotted, dissecting, and fascicularly surrounded by a stratum of (automatous, prorepent) "Oscillaria"-fibrils. Not only the ultimately enlarged (chlorophylliferous) brood-segments, but also the dark undulating fiber, form brood-balls (terminally). Its gelatine forms a cement of the loose sandy clay, and a home or abode for the Cladoniae (or bright-green foliolate lichens) as well as for grasses, etc.

front, and the cupular-compressed, dead, chlorophylline mass remains inert and void of life until devoured by Infusoria or the zymotic fungus. The cell-coat, likewise, is effete, while the large globular and somewhat acicularly-granulated incubus, after a few very wry contractions, at once widely opens a large, ciliate mouth, gaping across the sphere's surface; and disengaging or displaying a girdle of cilia round the rear part of the body, it immediately represents the *free-roving Vorticella* in full equipment.

Its subsequent "encystment," into a spherical cyst *densely covered with short prickles* (somewhat like the rim of a Heliopelta) and containing entrail-like designs, is well known.* Also, that it eventually bursts—*occasionally*, at least—and disgorges a peculiar sort of *wafer*-shaped, elliptical (not ellipsoidal!) cells, or nuclei, whose ulterior fate and abode, however, hitherto remained unknown.

The fact is, that they rise to the *surface*, where, on account of their shape, they *inhere*, as an almost imperceptible pellicle or stratum, which to the microscopic observer is the instantaneous index of the precise *focality* of the surface.

In this state, when no food is supplied, they long remain unaltered. When meat, bread or other nutritive matter is added, however, they *develop* (particularly where the absence of light prevents the confervaceous or green, chlorophylline growths from becoming paramount) into the smallest *Vorticellæ.* The center of the wafer-shaped disc, inherent in the denser surface of the water, protrudes downward into a little clear knoll or navel, which soon begins to *jerk*, representing as it were a pin-head of $\frac{1}{1000}$ line diameter on a little thread or coiled stalk; and, as the whole increases in size, it now constitutes the well-known *spirally pedunculate* Vorticella; pyriform-bell shaped, somewhat pitcher-mouthed, with cilia around the orifice and a clear granular *nucleus* or "germinal speck" inside.

The multiplication of the pedunculate Vorticellæ, by fission, lengthwise, and by budding-out, sideways, at the rear end, is sufficiently known. As the bud tears loose, there is yet no oral aperture visible. There is, however, a girdle of cilia at the *rear*, wherewith it performs an undulatory vibration, until it tears loose by spinning round; and after irregularly prancing about, and rebounding at head-long speed, within a few minutes it "settles" upon some suitable surface, with the ciliated rear end; and spinning out a *podetium*, or peduncle, often within a quarter of an hour, the rear cilia get applied downward to the body and disappear; while after a little time a fully-ciliated mouth now opens *in front.*

* In fig. 215, Carp. "Micr." (p. 446), the short prickles are omitted, B. to E.

As for its *retrograde* multiplications, when a Vorticella gets "sick," for want of air or food (as when kept between glass-plates held apart and glued round about, or cemented, to prevent evaporation), the body contracts to a perfect globe, with a big germinal point, "eye" or nucleus in the middle; the throat contracted, and the lifeless cilia standing around like the limb of a rose-calyx. The germinal speck, ogle or nucleus soon becomes immensely bloated, protruding out of the crown or ciliate aperture like a dim, hazy *balloon*, and then being either suddenly or gradually exploded, its almost invisible granular contents settle around and increase into a rather densely *punctuated cloud*, run up like a *cumulus;* its tips mostly warty as with (dotted) strawberries, a sort of primordial "framboësia." It is to this form that I wish to call particular attention, since it presents *the most minute phase of individual animate life* visible at represent under the known powers of the microscope: being the ultimate retrograde development-phase, as well as the first manifestation, common to all such soft primitive *sarcode* bodies, from the "Vorticellan" to the most bulky "Paramecian" forms. And from each little dot in these "clouds of life" a separate Vorticella can be seen to develop! It is here, indeed, at this first *visible* advent or exordium of animate life, and the resurrection of millions of germs through the spontaneous dissolution of a single one, that the last nubecular *microscopic* perceptions closely resemble the last nebular telescopic as well as the *theoretic* ones of Laplace's cosmogony.

For the present let us call such often repeated forms of retrograde self-dissolution and self-multiplication a germinal *nubecula.* Such likewise occur in a very closely analogous form in the self-maceration (of the engulfed pencil-beads and the enlarged "oidium"-joints) of the yeast or "zymotic" fungus. The difference being, that in the case of *animal* infusoria the dots remain affixed, and, after jerking apart, rapidly travel on separately with a vaccillating motion resulting from their warped surface (*true* Zooglœa Termo *Cohn; not* that of *Klob*), while in the case of the mucous or polypoid fungine diffluence (erroneously called by the above name by *Klob*), the component blunt-cylindrical Cacteria are not mutually fixed, but all simultaneously slowly move onward and apart in slimy *trails*, without a perceptible rotation, simply quivering, and ultimately enlarge into fibers. Of the *black* or "indissoluble" nebula-form of the zymotic or yeast-fungus I have already treated in the St. Louis Medical Reporter, Jan. 1st, 1868, (Zymotic Condition. etc.) and Proc. A. A. A. S., 1870, *et ante.* Neither the animal molecules nor the (coated) "Cacteria" join into file, as do the fermentic sarcode-vibrios, being *naked.*

The watchful observer will have opportunity of witnessing

another sort of "fertile dissolution," of the more bulky Vorticellæ, by the discharge of certain globular, granular "pellets," surrounded with other adhering and *jerking* particles—(probably the "acineta" of some authors)—while containing the "currant-shaped" yolks,—hereafter to be described, together with its "amœba" or pseudopodial dissolution, when treating of the so-called "*Paramecium Aurelia.*"

[To be continued.]

ART. V.—*On the application of Photography to the determination of Astronomical data;* by ASAPH HALL.*

ANY one who has witnessed a total eclipse of the sun must have felt his utter inability to make a correct description of the various features of the phenomenon, and must have wished for some means by which all these features, so suddenly and so grandly displayed, might be portrayed impartially and truthfully and in such a way that they could be subjected to a cool and leisurely examination. Such a means is furnished in a good degree by photography. A few photographs of the corona and protuberances of a total eclipse are far more trustworthy than all the hand sketches that have ever been made. It is true indeed that by the union of several observers and each one giving his attention to some specific point much may be learned, and some things perhaps that photography is not yet able to exhibit, but speaking generally we may say that photography combines the powers of all these observers and furnishes a record admirable for its truthfulness. Photography combines the powers of all these observers and furnishes a record admirable for its truthfulness. The beautiful photographs of the solar eclipse of Aug. 1869 obtained by Prof. Morton and Dr. Curtis, and those of the eclipse of 1870 by the English and American parties in Spain and Sicily attest the truth of this assertion; and the photographs of the moon by Messrs. Draper, Rutherfurd and De la Rue also give ample evidence of the value of photography when applied to descriptive astronomy. But that photography gives us the means for the exact measurement of angles and distances and thus of determining accurate astronomical data in the case of a solar eclipse or of a transit of a planet does not yet appear to be clearly established. In the hope of provoking discussion and investigation of the subject a brief review of what has been done in this application of the photographic method seems opportune, especially so, considering the extensive use that may be made of the method in observing the transit of Venus now near at hand.

* Read before the Washington Philosophical Society.

The first photographs of double stars, made for the purpose of determining by micrometric measurement their relative angle of position and distance, were those of Mizar and its companion, made at the Harvard College Observatory in April and May, 1857, by Messrs. Whipple and Black of Boston. Professor G. P. Bond has given in the Astronomische Nachrichten, No. 1105, the results of his measurements of the thirteen photographic images. The zero of the angle of position was found by moving the telescope in right ascension after an impression had been taken and taking a second one on the same plate. This process repeated gave a series of photographic images on the same plate and the right line passing through the series gave the direction of the daily motion of the heavens. The probable error of a single measurement of the photographic distance of the images was found to be $\pm$ 0″·12, or somewhat smaller than that of a direct measurement with the common filar micrometer. During the summer of 1857 many more photographs of this double star were taken, and in the journal above mentioned, No. 1129, Prof. Bond has given an elaborate account of the measurement of sixty-two photographic images. For this measurement of these images a new and improved micrometer was employed, consisting of an achromatic microscope with a magnifying power of 2200. Under this microscope the star images appeared as aggregations of minute drops of matter and looked like the result of a great number of vibrating and momentary impressions. They were generally symmetrical with a gradual condensation toward the center of the image, and the bisection of an image with the wire of the micrometer could be done with great exactness. The probable error of the center of an image was found to be $\pm$0″·051, and hence that of the distance of two such centers to be $\pm$0″·072. Adopting the estimate of Struve, $\pm$0″·127, as the probable error of a single measurement of a double star of this class with a filar micrometer, the measurement of the photographic images would have a relative value three times greater, or $= \left(\frac{0\cdot127}{0\cdot072}\right)^2$. The accuracy of the measurement is better shown by the numerical results obtained by Prof. Bond, which are as follows:

Mean Exposure.	Distance.	No. of images.
13ˢ	14″·31 $\pm$ 0·034	7
16	14 ·19 $\pm$ 0·035	7
18	14 ·18 $\pm$ 0·033	8
24	14 ·23 $\pm$ 0·035	8
25	14 ·15 $\pm$ 0·034	7
30	14 ·28 $\pm$ 0·034	7
33	14 ·19 $\pm$ 0·033	8
36	14 ·20 $\pm$ 0·032	10
24·5	14 ·21 $\pm$ 0·013	62

The application by Prof. Bond of photography to stellar astronomy was confined to stars brighter than the seventh magnitude, and with the hope probably of finding some encouragement of obtaining photographs of much fainter stars, he has discussed very fully in the Astronomische Nachrichten, No. 1158 and 1159, the effect of increasing the times of exposure of the photographic plates. The result which he arrives at is that "deficiency of light can be more than compensated for by a proportionate increase in the time of exposure;" and concludes that an exposure of ten minutes with the Cambridge Equatorial would give a photographic image of a star of the ninth magnitude. This, however, appears to be a question that can be decided only by actual experiment.

The last essay referred to closes Prof. Bond's work in stellar photography. He intended to resume the subject and was confident of being able to make photographic images of stars down to the ninth magnitude, but failing health and a desire to finish his work on the great nebula in Orion prevented him from undertaking any further experiments. Having participated in the work of measuring the photographic images and in reducing the measurements, and having a vivid remembrance of the labor performed, I take the liberty of stating my own estimate of the two methods of observing double stars, viz: the photographic method and that of direct measurement with a filar micrometer or heliometer. In the case of double and triple stars I have no doubt that the better method is that of direct measurement. The labor of setting the circles and finding the star is common to both methods, but during the time required to adjust properly the clock work and make a series of photographic images a practised observer would make and reduce a series of direct measurements. It is thus possible by the direct method more easily to repeat the observation under varied conditions of atmosphere, observer and instrument, and in this way to render the final result less liable to systematic errors. It is true that according to Prof. Bond's calculations, the photographic method is decidedly the more accurate, but some experience makes one, I think, distrustful of inferences drawn from the values of probable errors. The most dangerous errors of observation are those that are constant or systematic, and these the theory of probability does not and can not recognize. It is this class of errors which is the source of the large discordances frequently seen in different determinations of the same quantity while each single determination has apparently a very small probable error. It should therefore be the care of the observer to vary the circumstances of his observation in order to avoid systematic error, or to give it as much as possible the nature of those irregular errors which in the long run tend to eliminate themselves. Finally, it may be stated as a general

rule that, other things being equal, the simpler and more direct the method of observing, the better. In order to justify the interposition of any new process it must be shown that this process gives greater accuracy or greater rapidity of observing or both. Thus the chronographic method of observing transits is justified on the ground that it gives greater ease and rapidity of observing, since the gain in accuracy is scarcely sensible.

In the case of groups of stars like the Pleiades or Præsepe there would be a great advantage in using the photographic method provided the plates could be made sufficiently sensitive, so that images of stars of the ninth and tenth magnitudes could be obtained. Mr. Rutherfurd, who has done so much in astronomical photography, has made photographs of both the groups mentioned, and from his plates Dr. B. A. Gould has deduced positions of the stars. Dr. Gould's memoir on the Pleiades was presented to the National Academy five years ago, and it is to be regretted that it is not yet published.

The first application of photography to determine the times of contact in a solar eclipse was made by Mr. Warren De la Rue in the case of the eclipse of July, 1860. In the Philosophical Transactions, of the Royal Society of London, 1862, Mr. De la Rue has given a full account of his work, together with an engraving and description of the micrometer employed for measuring the photographs. The Kew heliograph was used in obtaining the photographs, an instrument designed by Mr. De la Rue for the purpose of making photographs of the Sun's disk. By means of a Huyghenian eye-piece the image of the sun was enlarged to a diameter of nearly four inches. Two position wires at right angles to each other were placed in the focus of the eye-piece at an angle of nearly 45° to a parallel of declination, and the final correction to the position of these wires was found by observing transits of the sun's limbs after the method proposed by Mr. Carrington. The wires being photographed on the plates their images furnished a means of finding the zero of position, and the plates were measured for the position angles of the cusps and their chords, also the radii of the sun and moon and the positions of their centers. By comparing the interval of time of two consecutive photographs with the measured position of the centers, the relative motion of the sun and moon was deduced and hence the times of contact which agree tolerably well with each other, but not so well perhaps as those of the ordinary direct observation. The value in arc of a single division of the measuring scale was found by measuring on the plates the radius of the sun in parts of the scale and then assuming a value of the sun's radius. A very doubtful correction of $-4''.1$ is deduced for the sum of the semidiameters of the sun and moon.

Mr. De la Rue speaks of having made some observations to determine whether in the process of drying the images had undergone any distortion, and says: "The result, however, proved that there was no appreciable contraction, except in thickness, and that the collodion film did not become distorted, provided the rims of the glass plates had been well ground." This point being a fundamental one appears worthy of further investigation. There is some uncertainty and vagueness about Mr. De la Rue's methods which do not give much confidence in the accuracy of his results, but on the whole he appears to have shown that the photographic method promises good results which is all perhaps that a first trial could be expected to do.

The next and last memoir published on this subject is that by Messrs. De la Rue, Balfour Stewart and Benjamin Loewy, on Solar Physics, Philosophical Transactions, 1869, giving an account of the positions and areas of the sun-spots observed with the Kew photoheliograph during the years 1862 and 1863. In order to determine the heliographical latitude and longitude of a spot two elements are required, viz: its angle of position and its distance from the sun's center at the time of observation. These elements were obtained by measuring the photographic plates, the position wires being similar to those used by Mr. De la Rue in the solar eclipse of 1860, and their zero being determined in the same manner. This memoir contains a large amount of interesting information concerning the position and areas of the solar spots, but the determinations of position are vitiated in some degree by the optical distortion of the instrument. The observers at Kew have made experiments to determine the amount of distortion, but no definitive result has yet been reached. They say that the following facts may be regarded as established: "1st, that the image of any object photographically depicted is liable to a distortion, which varies at different distances from the center of the field, and the amount of which may be determined for every instrument by methods similar to that employed by ourselves; 2d, that in our case the image of an object is larger when formed near the edge of the field than at the center, and that the amount of elongation of a unit of length at the center increases with its distance from the center." Their conclusion is that the inquiry is not sufficiently far advanced to justify any corrections of the positions of the spots on account of the effect of distortion, but they express the hope that at last they will be able to give thoroughly satisfactory constants for the effect of displacement in their instrument.

The photographs of the solar eclipse of August, 1869, have not yet been measured and discussed so far as I know, but it is pretty certain that all the images are affected by distortion which will in a measure render the results dependent and untrustworthy. It is to be hoped, however, that these pho-

tographic plates will be subjected to a careful examination in order that some estimate may be made of the extent of error to which they are liable. In the case of a solar eclipse, or of a transit of a planet over the sun's disk the photographic method has very great advantages over the observations of contact in many respects, and the errors to which it is subject are worthy of the most thorough investigation. The observation of a contact is uncertain on account of irradiation, and it is momentary also, so that if lost by a cloud, or in any way, the observer is compelled to view for several hours the phenomenon without being able to observe it. On the other hand when the sky is clear a photographic image can be obtained in an instant, and even if all the contacts be lost, valuable results might be secured if the readings of the photographic plates can be correctly reduced. Just here then is the point for experiment, investigation and invention, since it is most desirable that no doubt should remain as to the possibility of correctly measuring and reducing the photographic observations of the transit of Venus.

Mar. 25, 1871.

ART. VI.—*On Ralstonite, a new Fluoride from Arksut-Fiord;* by GEO. J. BRUSH.

THE recent exploitation of the Greenland cryolite has not only led to the discovery of crystallized cryolite, but has given to mineralogical science several new fluorides, two of which, thomsenolite and pachnolite, are found in beautiful crystallized forms.

I now call attention to another fluoride observed, a few months since, by Rev. J. Grier Ralston of Norristown, Pa. Mr. Ralston found a mineral in minute octahedrons associated with thomsenolite, and being unable to identify it, he sent it to Prof. Dana, by whom the specimens were passed over to me for examination.

The crystals of the new mineral are octahedral; and in some cases they are very minute, but occasionally one to one-and-a-half millimeters in diameter. They are often implanted on the thomsenolite crystals, and also apparently intercrystallized with this species, making it extremely difficult to separate the new mineral sufficiently pure for analysis. The planes of the octahedron are often tinged slightly yellow, and many of them are dull and iridiscent, owing to an excessively thin film of oxide of iron, and hence exact measurement of the inclinations of the faces cannot be made. But they appear to be symmetrical with equilateral faces, and, in some cases, have all the solid angles replaced by a minute plane. With so regular a habit and the

ıes alike in lustre I cannot doubt that they are isometric ıhedrons, and hence that the small plane on the angles is a ic plane.

'he mineral is colorless to white, with a vitreous luster, and a hardness greater than fluorite, equal to about 4·5. ›cific gravity, taken on 25 milligrams, gave 2·4.

n the closed tube the mineral whitens, yields water at first, a gives off fumes and a copious white sublimate, while the ls of the tube are etched. The vapor in the tube, as well he water, reacts acid. Even at a very elevated temperature heated fragment retains its original form and does not fuse. the open tube the mineral gave similar reactions.

}.B. on charcoal a faint white sublimate was observed. In platinum forceps the mineral whitens without fusion and ›rs the flame a soda-yellow ; moistened with sulphuric acid coloration was unchanged. Heated with cobalt solution in platinum forceps the mineral assumed a bright alumina-e. In salt of phosphorus the substance was readily dis-ved, giving a colorless bead in both O. and R.F. In a soda d it dissolved with effervescence.

'he mineral was found on close examination with a magni-to be so intimately associated with thomsenolite, that it was med impracticable to separate a sufficient quantity for any ıg more than a preliminary qualitative examination in the way. A small portion, some 30 milligrams, selected with at care to ensure purity, was, decomposed in a platinum cap-ɜ by sulphuric acid. It gave off fluohydric acid, etching a ss plate, and on solution it gave with reagents a precipitate alumina, with evidences of the presence of lime and soda. th the spectroscope, the pure mineral alone gave only the a line, but when even a very minute speck of thomsenolite associated with it, the lime line was very marked. The ıtion from which alumina was separated afforded on evapora-ı to dryness a minute residue, which, when examined with spectroscope, gave both soda and lime lines.

:t therefore appears that the mineral under examination is entially a hydrous fluoride of aluminum with probably a all amount of calcium and sodium. Its isometric form, and infusibility, distinguishes it from all other fluorides yet de-ibed as occurring at the cryolite locality in Greenland.

The only mineral which in general chemical characters proaches it is the fluellite from Stenna-Gwyn in Cornwall. is rare mineral, according to Wollaston, is a fluoride of alu-num, but it occurs in elongated orthorhombic octahedrons. ese facts are, I think, sufficient to warrant the conclusion that Greenland octahedral mineral is a new fluoride, and I pro-se for it the name *Ralstonite*, after its discoverer.

ART. VII.—*Notes on the Primordial Rocks in the vicinity of Troy, N. Y.;* by S. W. FORD.

IN view of the prevailing uncertainty respecting the age of the rocks of that portion of the Taconic series of Professor Emmons lying east of the Hudson river, I was led several years ago to undertake the investigation of some of these rocks in my own neighborhood, though I had but few hopes of learning anything essentially new about them. It soon became apparent that much valuable information might be obtained from them; and from certain facts which early came under my observation I was induced to continue their study. I propose here to notice briefly some of the more noteworthy results thus far obtained.

The rocks immediately east of the Hudson at Troy are fine black, glazed shales, with occasional sandy layers, and have usually been regarded as belonging to the Hudson River formation. They have been greatly crushed, but their general dip is evidently eastward, and at a high angle. They extend eastward about half a mile, and form a hill of considerable magnitude within the city limits. Following the course of this hill northward, we find them frequently well exposed in railway cuttings, and before reaching Lansingburgh, which is three miles distant, in a bold elevation several hundred feet in height.

The only fossils which these shales have afforded, are the obscure form described under the name of *Discophylum peltatum* (Pal. N. Y., vol. i, p. 277, plate lxxv, fig. 3), and two or three species of graptolites, the latter having been but recently obtained. The graptolites resemble closely certain well known Hudson river forms, but whether certainly identical I am at present unable to state. If truly Hudson river shales, then the absence of any other fossils in these rocks except those above mentioned appears not a little remarkable.

Upon the east, after an interval of concealment varying somewhat in different localities, these shales are followed by the widely different rocks of the "Taconic" series likewise dipping eastward, and apparently at about the same angle. The best exposures of these rocks in this vicinity occur opposite the central portion of the city, where they are brought to view in a number of abrupt, quickly concealed outcrops. These outcrops trend northerly and southerly, and appear to be all constructed upon the same pattern, having on the west a steep, on the east a more gradual slope. Only the western faces are naturally exposed. This uniformity of structure is very striking, and there are reasons for believing that it has resulted largely from successive short, sharp folds in the strata, of which we have a fine example in the rocks east of Lansingburgh; but as nearly

the whole district is covered with a thick sheet of drift, and the rocks bear evidence of extensive faulting, much further study will be necessary before it will be fully understood.

These outcrops generally consist for the most part of coarse red and yellow weathering slates and shales, with occasional thin-bedded sandstones; but the most of them are supposed, and four of them are known, to hold subordinate limestone deposits. Of these deposits the two western-most individually consist of a few courses of thick-bedded limestone, and of irregular, sometimes lenticular, sparry and frequently pebbly masses, varying from one to several hundred pounds in weight, imbedded in a coarse, dirty-looking arenaceous matrix; while the others form tolerably compact, even-bedded limestones, with an abundance of scattered black nodules, from twenty-five to thirty feet in thickness.

So far as investigated, these limestones have been found to be highly fossiliferous, though the fossils are usually in a very fragmentary condition. From two of them—one of the conglomerates and one of the even-bedded masses—the writer has made frequent collections during the last three years. With a single exception the same species occur in both. Up to the present time they have yielded eighteen species, which are distributed as follows:

Protozoa (*Archæocyathus*)	1	species.
Brachiopoda	7	"
Lamellibranchiata	1	"
Gasteropoda	1	"
Pteropoda (*Hyolithes*)	2	"
Annelida (*Salterella*)	1	"
Crustacea	5	"
Total,	18	"

Of these, six—*Obolella* (*Avicula?*) *desquamata* (Hall), *O.* (*Orbicula?*) *crassa* (H.), *O.* (*Orbicula*) *cœlata* (H.), *Metoptomas rugosa* (H.), *Theca triangularis* (H.), and *Agnostus lobatus* (H.)—were figured and described in the first volume of the Paleontology of New York in 1843, from this locality; and two—*Conocephalus* (*Atops*) *trilineatus* (Emm.) and *Olenellus* (*Olenus*) *asaphoides* (H.), from Greenwich, Washington county. All the rest are new or undescribed.*

Desiring further information in regard to certain of these new species, I several months since wrote Mr. E. Billings, Paleontologist of the Geological Survey of Canada, at the same time giving him a list of the species in my possession from this

* Unless one of them should prove identical with the species of *Cypricardia* figured by Emmons (American Geology, p. 113, plate 1, fig. 1.)

quarter. In reply Mr. B. informed me that he was just then engaged upon a collection of new fossils from the Lower Potsdam formation below Quebec, which he strongly suspected to be identical with my own; and on comparison it was found that fifteen out of the eighteen species from Troy were held by us in common, and shown to be perfectly identical. Such an unlooked for result of course surprised us greatly. That the Lower Potsdam formation below Quebec, and the western portion of the Taconic series near Troy* are of the same age, there seems now but little room for doubt.

Two very characteristic fossils of this formation are the opercula of two species of *Hyolithes*, upon which I communicated a note in the preceding number of this Journal. One of them was there described as a "minute, circular species, with four pairs of lateral muscular impressions and two smaller, dorsal, all radiating from a point near one side;" the other as "larger, and like a *Discina* on the outside." The former occurs quite abundantly in the Troy limestones, and is a very beautiful little object. It varies in size from a mere point to a diameter of three lines. Perfect specimens have a rich, polished appearance. The other occurs more rarely. As might naturally be expected, these rocks contain immense numbers of *Hyolithes*. Indeed, large portions of the limestone are often almost wholly composed of them.

Without doubt this formation in New York will yet afford many new species. The even-bedded limestones east of Troy, to which especial attention has been given, as well as portions of the conglomerates, are literally loaded with fossils, and promise richly to repay investigation for a long time to come. Their associated slates, shales and sandstones have as yet afforded no fossils. Near Lansingburgh, however, where what is at present regarded as a lower member of the formation, consisting of heavy and thin-bedded gray sandstones with interstratified black slates, is exposed, a few obscure Fucoids have been found, but these rocks have been but imperfectly investigated. Neither the thickness nor precise eastern limit of this formation has yet been ascertained.

Troy, N. Y., May 24, 1871.

* These rocks have hitherto been referred, though with some doubt, to the Calciferous portion of the Quebec Group; but all modern investigations in our older strata have steadily pointed to their higher antiquity; and it is simply justice to state that, by several geologists besides those who have adopted Prof. Emmons' views of their age, this has long been suspected.

Art. VIII.—*Notice of some new Fossil Mammals from the Tertiary Formation;* by Professor O. C. Marsh of Yale College.

In association with the Reptilian fossils collected by the Yale College party last summer, and already described in this Journal,* numerous remains of Mammals were also discovered, and in the following article some of the more interesting new species are briefly characterized. A few species from the other Tertiary lake-basins of the Rocky Mountains have been included, as they throw considerable light on the ancient sub-tropical fauna of that region. The present notice is merely preliminary to a full description, with illustrations, now in course of preparation.

Titanotherium? anceps, sp. nov.

The largest extinct mammal discovered by our party in the Green River basin was apparently one of the rarest; and the remains obtained, although in themselves characteristic, include, unfortunately, none of the teeth sufficiently well preserved to afford generic characters. The single species thus indicated has accordingly been referred, with a doubt, to the genus *Titanotherium*, seemingly a near ally, until the discovery of additional material clears up the question of its exact affinities.

The specimens discovered, which evidently pertained to three different individuals, mainly consist of several dorsal vertebræ, the distal end of a humerus, the greater portion of a tibia, and some of the smaller bones of the extremities. They indicate a Pachyderm, much larger than any other known mammal from the same deposits, and about two thirds the size of *Titanotherium Prouti*, from the Tertiary basin east of the Rocky Mountains. The anterior dorsal vertebræ preserved have both articular faces slightly concave, thus distinguishing the species at once from *T. Prouti*, which has in this part of the series the front vertebral face very convex, and the posterior face concave. Another marked difference is seen in the tibia, which at its proximal end has the femoral articular surfaces contiguous, with no prominent elevation between them, resembling in this respect some of the Proboscidea.

Measurements.

Length of anterior dorsal vertebra, on lower surface,	2	inches	2	lines.
Width of posterior face between rib cavities,	3	"		
Height of posterior face,	2	"	5	"
Transverse diameter of tibia at proximal end,	4	"	10	"
Fore and aft diameter,	4	"	3	"
Transverse diameter at distal end,	3	"	11	"
Fore and aft diameter,	3	"	3	"

* Vol. i, 1871, pp. 192, 322, and 447.

The remains were found by Lieut. Wann and the writer, in the "Mauvaises Terres" deposits near Sage Creek, Western Wyoming. The geological horizon is lower Miocene, or perhaps Eocene.

Palæosyops minor, sp. nov.

This species is indicated by a molar tooth, from the right lower jaw, and probably by some other less characteristic remains. The tooth, which is apparently from near the middle of the series, is of the *Palæotherium* type, and nearly resembles in its main characters the corresponding molar of *Palæosyops*. The crown is composed of two united, antero-posterior lobes, with crescent-shaped summits. The anterior lobe is the more elevated, and the posterior has a greater fore and aft extent. The animal thus represented was apparently about as large as the South American Tapir, and less than one half the size of *Palæosyops paludosus* Leidy,* from the same deposits.

Measurements.

Antero-posterior diameter of lower molar,	10	lines.
Transverse diameter of front lobe, at summit,	5·	"
Transverse diameter of posterior lobe, at summit,	5·6	"

The only known specimens of this species were found by the writer at Grizzly Buttes, near Fort Bridger, Wyoming, in the same deposits as the preceding species.

Lophiodon Bairdianus, sp. nov.

The remains on which this species is based consist of portions of several skeletons, with numerous teeth which show considerable variation in size and other characters of minor importance. The various specimens indicate an animal somewhat smaller than the modern Tapir of South America, but much larger than the *Lophiodon modestus*,† founded by Dr. Leidy on a tooth from the same Tertiary beds that afforded the fossils under consideration. From the latter species, so far as it is now known, the present specimens may be readily distinguished, moreover, by the enamel of the teeth, which, instead of being coarsely wrinkled, is nearly smooth, or marked by very delicate, irregular striæ.

Measurements.

Length of portion of upper jaw, enclosing the three posterior molars,	25·	lines.
Antero-posterior diameter of last upper molar,	9·	"
Transverse diameter of same,	10·25	"
Length of fragment of lower jaw with three posterior molars,	25·	"

* Proceedings Philadelphia Academy of Natural Sciences, 1870, p. 113.
† Proceedings Philadelphia Academy of Natural Sciences, 1870, p. 109.

The specimens now representing this species, which is one of the most common fossil mammals in the earlier Tertiary of Western Wyoming, were found by G. B. Grinnell, J. W. Griswold, C. W. Betts, A. H. Ewing, J. M. Russell, and the writer, at various localities near Fort Bridger, and on the White River, in Eastern Utah. The species is named in honor of Professor S. F. Baird, of the Smithsonian Institution.

Lophiodon affinis, sp. nov.

A second and somewhat smaller species of the same genus, closely allied to the preceding, is indicated by various fragmentary remains, including several molar teeth in an excellent state of preservation. A comparison of the last upper molar with that of *L. Bairdianus*, shows, aside from the smaller size, a marked difference, especially in the contour of the crown, which has a deep notch in the outer posterior margin of the base, between the external tubercles in which the transverse ridges terminate. In the species just described, the margin is here nearly straight. The present specimen, moreover, has the small anterior external tubercle more prominent, and less closely connected with the adjoining ridge. This tooth is larger than the corresponding one of *Lophiodon modestus*, and has quite different proportions. The enamel, also, is similar to that in the preceding species.

Measurements.

Antero-posterior diameter of last upper molar........	7·1	lines.
Transverse diameter of same,........................	8·3	"
Antero-posterior diameter of penultimate upper molar,	8·	"
Transverse diameter of same,........................	8·	"

The principal specimens on which this species is established were found by H. D. Ziegler, in the Mauvaises Terres beds, near Marsh's Fork, Wyoming.

Lophiodon nanus, sp. nov.

A small, well marked species, apparently of the genus *Lophiodon*, is represented by a number of fossils collected by the Yale party at various localities. The most characteristic of these specimens is a right upper jaw containing a series of four premolars, and three molars, and part of the corresponding left jaw with several teeth of the same animal. The molars differ especially from those of the two preceding species, in having a much shallower valley between the two transverse ridges, and in having a strong basal ridge, or shelf, at the external posterior corner of the crown. The enamel of the whole series is very smooth. The species was probably about two thirds the size of *L. modestus*.

Measurements.

Length of portion of upper jaw, containing seven posterior teeth,	26·	lines.
Length of same, with three last molars,	13·7	"
Antero-posterior diameter of last upper molar,	5·	"
Transverse diameter of same,	5·25	"

The remains now known to represent this species were discovered by C. W. Betts, H. B. Sargent, and the writer, in the Tertiary strata at Grizzly Buttes, near Fort Bridger.

Lophiodon pumilus, sp. nov.

A still more diminutive species, of the same, or a nearly related, genus, is indicated by several specimens, including a fragment of a left upper jaw, containing three premolars and the two succeeding molar teeth. The species may easily be distinguished from the small one above described, by the presence, on the outside of the superior teeth, of a strong, continuous, but irregular basal ridge, which, at the external angle of the crown, replaces the elevated tubercle present in all the molars of the species already noticed. The present specimen may also be distinguished from *L. nanus*, by the form of the last two upper premolars, which in the latter have their greatest transverse diameter behind the center, while the reverse is true of these premolars in the species under consideration.

Measurements.

Length of portion of upper jaw, with three premolars, and next two molars,	14·	lines.
Antero-posterior diameter of penultimate upper molar,	3·25	"
Transverse diameter of same,	4·	"

The only specimens at present known to represent this species were found by C. T. Ballard, in the Tertiary beds near Marsh's Fork, Western Wyoming.

Anchitherium gracilis, sp. nov.

The Green River Tertiary basin of Wyoming apparently contains very few extinct solipedal mammals, one or two fragments only being all our party secured during several weeks of explorations. In the Uintah or southern basin, however, especially near the White River of Eastern Utah,* remains of this group are more abundant, and some characteristic specimens were obtained. Among these, were three lower jaws, with many of the teeth in good preservation. They represent an animal less than one half the size of *Anchitherium Bairdi* Leidy, and apparently belonging to the same genus. There are seven premolar and molar teeth, with essentially the same constitution as in that

* This Journal, vol. i, p. 196, March, 1871.

The first premolar has but one fang, and between this symphysis there are no teeth. On the inner face of nus there is a shallow, sickle-shaped impression, with the rected forward, and terminating under the first premolar.

Measurements.

of portion of lower jaw, with six posterior teeth,	23·58	lines.
of same with three posterior teeth,	12·5	"
posterior diameter of last lower molar,	5·	"
rse diameter of same,	2·	"

ıbove specimens were discovered by C. T. Ballard and the on the north side of the White River, in Eastern Utah. ɔlogical horizon is upper Eocene, or lower Miocene.

Lophiotherium Ballardi, sp. nov.

ıall Pachyderm, apparently nearly related to the genus *herium*, is indicated by a fragment of a right lower jaw, ıe last two molars, and a few less important remains. ecies thus represented appears to have been about two he size of *Lophiotherium sylvaticum*, recently described Leidy from the same Tertiary basin in which these fos-e found,* and the teeth, so far as known, have nearly the ɔmposition. Those preserved in the present specimen ewhat worn, showing that the individual was fully adult. amel, especially on the sides of the crown, is much d, and thus the external basal ridge is rendered strongly l.

Measurements.

posterior diameter of last lower molar,	4·4	lines.
rse diameter of same,	2·1	"
posterior diameter of penultimate lower molar,	3·2	"
rse diameter of same,	2·25	"

species is named for the discoverer, Mr. C. T. Ballard, of e party, who obtained the specimens here described at Buttes, Western Wyoming.

Elotherium lentus, sp. nov.

presence of numerous Suilline Pachyderms in the Green Tertiary basin was clearly established during the inves-s of our party by the discovery of several extinct species, rent from any hitherto described. One of these, which ly belonged to the genus *Elotherium*, is represented by a ragment of a left lower jaw, with the last molar in fine ation. This specimen indicates a species about one half e of *Elotherium Mortoni* Leidy, which is comparatively nt in the lower Tertiary deposits east of the Rocky Moun-

* Proceedings Philadelphia Academy of Natural Sciences, 1870, 126.

tains. The upper surface of this last lower molar is composed of two transverse pairs of conical lobes, with a single posterior one on the median line. The anterior inner cone is larger than its fellow, and has its summit bifid. In the next pair, which are much less elevated, the external lobe is the larger. The posterior cone is low, and shows a tendency to subdivide. There is a basal ridge in front, and indications of its continuation on the external border. The enamel is finely corrugated. There is a prominent rugose tubercle on the inner superior margin of the lower jaw, a short distance behind and above the last molar.

Measurements.

Antero-posterior diameter of last lower molar,	9·	lines.
Greatest transverse diameter of same,	5·	"
Transverse diameter between first and second pair of cones,	4·4	"

The specimen on which this species is established was found by the writer, in October last, in the Tertiary beds, on Henry's Fork, Wyoming.

Platygonus Ziegleri, sp. nov.

Remains of another Suilline animal, fully as large as the modern *Sus scrofa*, were obtained in the same Tertiary beds with the last species. The most characteristic specimens discovered are a number of upper premolar and molar teeth, which agree so nearly in general composition with those of *Platygonus*, that they may very properly be referred to that genus. One prominent character in these teeth, especially the anterior ones, is the remarkably strong basal ridge, which, on the inner border at least of the first and second premolars, exceeds in breadth that in *Platygonus compressus* LeConte, although on the posterior margin it is less developed than in that species. The crowns of all the upper premolars are composed of a single transverse pair of cones, closely united. The second premolar in this specimen has a greater fore and aft diameter than the third. The enamel of all the teeth is rugose, as in the modern Peccaries.

Measurements.

Length of fragment of upper jaw, containing the three premolars,	18·5	lines.
Antero-posterior diameter of first upper premolar,	6·	"
Transverse diameter of same,	6·	"
Antero-posterior diameter of second upper premolar,	6·5	"
Transverse diameter of same,	7·3	"
Antero-posterior diameter of third upper premolar,	6·2	"

The species is named for H. D. Ziegler, of Yale College, who discovered the specimens on which the present description is based. The locality was at Grizzly Buttes, near the base of the Uintah Mountains.

Platygonus striatus, sp. nov.

d Suilline species, nearly related apparently to the quite equaling it in size, is indicated by portions of ' jaws, with a few of the anterior teeth, collected by in the Pliocene strata of Northern Nebraska. In one cimens, the second left premolar is well preserved, and stic. It has the same general composition as the corg tooth in *Platygonus compressus*, but, in addition to larger size, it is proportionally broader, and has the ;e in front less developed. The posterior basal ridge, , is expanded into two rudimentary tubercles. The marked by delicate irregular striæ, mostly parallel with of the crown, and to this ornamentation the specific :rs.

Measurements.

' portion of left lower jaw containing first four	25·	lines.
' same, with first three teeth,..................	17·	"
ısterior diameter of second lower premolar,..	6·2	"
e diameter of same,........................	5·8	"

ove specimens were found by the writer, in July last, liocene sands, near the head-waters of the Loup Fork ebraska.

Platygonus? Condoni, sp. nov.

esent species is founded on a portion of a right upper ıining the three posterior molars. The specimens evi:longed to a true Suilline mammal, at least equal in the last two described. The exact generic relations of es cannot at present be ascertained, but it differs esfrom any known recent or extinct American species of p in several particulars. One of the most marked of he unusual elongated fore and aft proportions of the r molar, which has to the diameter of the penultimate ratio of three to two. The crown of the posterior :omposed of two transverse pairs of principal cones, the ' being the larger, and a posterior lobe, which is parided into three tubercles. The enamel is smooth, and .o basal ridge on the sides of the teeth preserved.

Measurements.

f jaw enclosing last three upper molars,.......	27·	lines.
ısterior extent of last molar,...................	12·	"
ıe diameter of same, through anterior lobes,...	7·	"
ısterior extent of penultimate molar,..........	8·	"

ɔecies is named for Rev. Thomas Condon, who discovspecimen described, in the Pliocene beds of Oregon.

Dicotyles Hesperius, sp. nov.

A new and interesting small Suilline mammal is well represented by a portion of a right upper jaw, with the last premolar, and the succeeding three molars, all in excellent preservation. The teeth indicate an individual fully adult. They have nearly the composition of those of the modern Peccaries, and evidently belonged to the same, or a closely related, genus. The species is well marked, and was apparently not more than one half the bulk of *Dicotyles torquatus*. The crowns of the molars have a more rhombic outline than in that species, and a more distinct valley between the anterior and posterior pair of cones. The basal ridge is also more strongly developed, especially on the outer margin, where it is continuous. In other respects the composition of these teeth is very similar in the two species. The last upper premolar in the present specimen, however, differs widely from the corresponding tooth in any of the known Peccaries, living or fossil, resembling most nearly in its composition the second premolar of *D. torquatus*. The latter has, however, the single posterior cone distinct, while in the species under consideration it is connate with the anterior outer tubercle. The upper dental series is here somewhat curved outwardly, and not on a line, as in the living Peccaries.

Measurements.

Length of part of upper jaw with four posterior teeth,..	19·	lines.
Length of same, with three molars,..................	15·2	"
Antero-posterior diameter of last upper molar,.........	5·6	"
Transverse extent of same,..........................	4·	"
Antero-posterior diameter of penultimate upper molar,	5·4	"

This specimen, for which the writer is likewise indebted to Rev. Mr. Condon, is from the same locality and geological horizon as the species last described.

Hypsodus gracilis, sp. nov.

This species was about the same size as *Hypsodus paulus*, a small mammal described by Dr. Leidy from the lower Tertiary basin in Wyoming, and supposed by him to indicate an animal probably allied to the suilline family.* It may readily be distinguished from that species, especially by the first true molar of the lower jaw, which is proportionally narrower in front, and broader at its posterior margin. There is also on this tooth a strong external basal ridge, and, at the anterior inner angle, a prominent projection, which is wanting in *H. paulus*. The lower jaw is, moreover, deeper and more compressed in the region of the premolars.

* Proceedings Philadelphia Acad. Nat. Science, 1870, p. 109.

Measurements.

Length of part of lower jaw containing first molar and last two premolars,	5·1	lines.
Antero-posterior diameter of first lower molar,	2·	"
Transverse diameter through posterior lobe,	1·6	"
Antero-posterior diameter of last lower premolar,	1·6	"

The specimens representing this species at present were found by the writer, at Grizzly Buttes, Wyoming.

Limnotherium tyrannus, gen. et sp. nov.

A somewhat larger pachyderm, but distantly allied apparently to the two small species last described, is represented by the anterior portions of two united lower jaws, with several teeth, and a few other fragmentary remains. These specimens appear to indicate a genus quite distinct from any hitherto known, but additional remains will probably be required to determine its exact affinities. The teeth of the lower jaws are twenty in number, and form an uninterrupted series, which may be divided as follows:—Incisors 2–2, canines 1–1, premolars 4–4, molars 3–3. The incisors are small, and crowded together. The canines are large, nearly round at the base, and evidently formed most efficient weapons. The first and second premolars had but a single fang. The two anterior molars are in excellent preservation, and have their crowns composed of four principal cones. The first is at the anterior outer angle; the second just behind this, on the inner margin; the third at the outer posterior angle; and the fourth and smallest at the inner posterior corner, separated from the others by a deep pit. Each molar has a rudimentary double tubercle on the anterior margin, and a moderate basal ridge, except on the inner side.

Measurements.

Length of dental series of lower jaw,	18·	lines·
Antero-posterior extent of three molars,	7·5	"
Transverse extent of four incisors,	3·	"
Length of symphysis,	8·5	"
Depth of lower jaw below last molar,	5·15	"
Depth below last premolar,	6·	"
Antero-posterior extent of first lower molar,	2·5	"
Transverse diameter of same,	2·	"

The specimens here described were found by the writer near Dry Creek, Western Wyoming, in deposits which are probably of Upper Eocene age.

Limnotherium elegans, sp. nov.

A diminutive mammal is represented in our collections by portions of two lower jaws, with several teeth, which have so

nearly the composition of those in the preceding species that they undoubtedly belong to the same, or a nearly related, genus. One of these specimens contains the last premolar, and the two succeeding molars. In the latter, the two anterior cones form a transverse pair, and are not oblique as in the larger species. The posterior pair of tubercles, also, are nearly on a transverse line.

Measurements.

Length of fragment of lower jaw, enclosing last premolar and three molars,	7·5	lines.
Antero-posterior diameter of second lower molar,	2·	"
Transverse diameter of same,	1·6	"

The only two specimens of this species now known were found by the writer at Grizzly Buttes, near the base of the Uintah Mountains, in Wyoming.

Yale College, New Haven, June 5th, 1871.

ART. IX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 16.—*On the Atomic Weights of Cobalt and Nickel;* by RICHARD H. LEE.

THE atomic weights of cobalt and nickel have long been subjects of controversy, but though much time and labor have been spent upon them, the results arrived at are not as satisfactory as could be desired.

Under these circumstances Prof. Gibbs suggested to me a new investigation of the subject. Before giving an account of my own methods and results, I will state briefly those of other chemists. Rothhoff,* in 1826, first endeavored to ascertain the atomic weights of cobalt and nickel. He determined the amount of chlorine in the respective chlorides, by means of silver, and from a single analysis of each chloride, obtained for cobalt the equivalent 29·55, and for nickel the equivalent 29·60. As the methods of separating the two metals were at that time imperfect, and as but a single analysis was made in each case, Rothhoff's results can hardly be considered as deserving of confidence.

Erdmann† and Marchand, in 1852, determined the atomic weight of nickel by reducing nickelous oxide in hydrogen. Their results varied between 29·1 and 29·3, and they regarded the lower number as more probably correct. It seems at least possible that the nickel they employed contained traces of cobalt. The subject was again taken up by Schneider‡ in 1857.

* Poggendorff's Annalen, vol. viii, p. 184–5.
† Annalen der Pharmacie, vol. lxxxii, p. 76.
‡ Poggendorff's Annalen, ci, p. 387.

Pure metallic cobalt was prepared by igniting chloride of purpureocobalt in hydrogen. The metal was then dissolved in chlorhydric acid and precipitated by sodic carbonate. The carbonate was washed, and then digested with oxalic acid, the resulting oxalate again washed, burned in a current of oxygen and the oxide reduced by hydrogen. In other portions of the oxalate the carbon was determined by combustion with cupric oxide.

The following table gives a summary of the results obtained:

	Oxalate taken.	Cobalt found.	Carbon found.	Equivalent Ꞓo.
1.	1·6355 2·3045	32·552 pr. ct.	13·024 p. c.	29·993
2.	1·1070 1·9010	32·619 "	13·041 "	30·015
3.	2·3090 4·0580	32·528 "	13·005 "	30·014
4.	3·0070 5·3500	32·523 "	13·014 "	29·989
			Mean,	30·003

Determinations of the atomic weights of cobalt and nickel were also made in 1857 by Marignac.* Cobaltous sulphate was purified by repeated crystallization and a weighed quantity of the salt heated so as to expel the acid. The resulting oxide was then heated with a known weight of silicate of lead so as to expel the excess of oxygen over and above that required to form cobaltous oxide ꞒoO. The results obtained varied between 29·32 and 29·38.

Crystallized cobaltous chloride dried at 100° was found to retain one atom of water. Three determinations of the chlorine in this salt by means of silver, gave for the atomic weight of cobalt 29·42 to 29·51. Anhydrous cobaltous chloride was obtained by heating the crystallized salt with sal-ammoniac, in a current of dry chlorine or dry chlorhydric acid gas. The salt almost always however left a slight residue insoluble in water. Five analyses of the anhydrous salt gave results varying from 29·36 to 29·42.

In 1859 Dumas† turned his attention to the subject. Perfectly pure metallic cobalt was dissolved in nitro-muriatic acid, the solution evaporated to dryness with frequent additions of chlorhydric acid, and the cobaltous chloride submitted to a red heat. In a second preparation from a different sample of metal the chloride was dried in vacuo. In this manner the following results were obtained:

* Bibliothique Universelle de Geneve, Nouvelle series, vol. i, p. 373.
† Ann. de Chimie et de Physique, 3d series, vol. lv, p. 148.

	$CoCl_2$.	Silver.	Equivalen
1	2·352	3·9035	29·57
2	4·210	6·990	29·54
3	3·592	5·960	29·59
4	2·492	4·1405	29·50
5	4·2295	7·0255	29·51

The mean of these five determinations is 29·54. In the chloride was dissolved in boiling water and the solu lowed to cool before precipitating with $AgNO_3$. The chloride was reduced in hydrogen. The method empl the preparation of pure cobalt is not stated.

Russell* determined the atomic weights of cobalt an in 1863. Pure metallic cobalt was prepared by igniting of purpureocobalt in hydrogen. The metal was diss nitric acid and the solution evaporated and strongly The black oxide obtained was ignited in a current of di-oxide, by which it was converted into light brown c oxide CoO, which was then reduced by pure hydrogen. ting two trial experiments, the results obtained were as

	CoO.	Cobalt.	Cobal
First sample, 1	2·1211	1·6670	78·
2	2·0241	1·5907	78·
3	2·1226	1·6673	78·
4	1·9947	1·5678	78·
5	3·0628	2·4078	78·
		Mean,	78·
First specimen twice purified—			
1	2·1167	1·6638	78·
2	1·7717	1·3924	78·
3	1·7852	1·4030	78·
		Mean,	78·
First specimen three times purified—			
1	1·6878	1·3264	78·
2	2·2076	1·7350	78·
		Mean,	78·
Second specimen—			
1	2·6851	2·1104	78·
2	2·1461	1·6868	78·
		Mean,	78·
Third specimen—			
1	3·4038	2·6752	78·
2	2·2778	1·7901	78·
3	2·1837	1·7163	78·
		Mean,	78·

* Annalen der Pharmacie, vol. cxxvi, pp. 322–336.

The mean of all the results is 78·5926, from which we find for the equivalent of cobalt on the old system 29·37.

In 1866 the subject was taken up by Sommaruga,* who determined the amount of metallic cobalt in chloride of purpureocobalt by reduction in a bulb tube with hydrogen. His results were as follows:

	Salt taken.	Cobalt found.	Equivalent.
1.	0·6656	0·1588	30·002
2.	1·0918	·2600	29·929
3.	0·9058	·2160	29·982
4.	1·5895	·3785	29·926
5.	2·9167	·6957	29·992
6.	1·8390	·4378	29·916
7.	2·5010	·5968	30·009
		Mean,	29·965

Winkler,† in 1867, determined the atomic weight of cobalt by heating a known weight of the metal with a perfectly neutral solution of double chloride of gold and sodium. The cobalt was obtained by the reduction of chloride of purpureocobalt.

	Salt taken.	Gold found.	Equivalent of Co(Au=196.)
1.	0·5890	1·3045	29·497
2.	0·3147	0·6981	29·451
3.	0·5829	1·2913	29·492
4.	0·5111	1·1312	29·518
5.	0·5821	1·2848	29·522
		Mean,	29·496

Finally, in 1869, Weselsky‡ made a new determination of the atomic weight of cobalt by finding the quantity of metallic cobalt in weighed quantities of cobalticyanide of aniline-ammonium and of ammonium. The results were as follows:

	Cobalt salt.	Cobalt found.	Equivalent.
1.	0·8529 gr.	0·1010	29·44
2.	0·6112 "	0·0723	29·38
3.	0·7140 "	0·0850	29·59
4.	0·9420 "	0·1120	29·54
1.	0·7575 "	0·1160	29·46
2.	0·5143 "	0·1130	29·55
		Mean,	29·48

The first four analyses were made with the anilin, the last two with the ammonium salt. These are the only determinations of the atomic weight of cobalt which I have been able to find, and I will therefore pass to my own analyses.

* Sitzungsberichte der Wiener Akad., vol. liv, p. 50.
† Zeitschrift für Anal. Chemie, 1867, p. 18.
‡ Berichte der Deutcshen Chem. Gesellschaft, 1870.

Commercial cobaltic oxide was treated in a large porcelain crucible with enough strong sulphuric acid to make it into a stiff paste. The crucible was then placed in a muffle furnace and heated for some time, at first gently and afterwards to low redness. The sulphate obtained was dissolved, filtered and submitted for some time to a current of sulphydric acid gas, by which copper, arsenic, &c., were removed. The filtrate was treated with chlorine water to peroxydize the iron present and then allowed to stand for 48 hours in contact with baric carbonate, the whole being frequently and thoroughly stirred. In this manner iron and manganese were almost wholly removed. The filtrate was then treated with a large excess of baric carbonate, and cyanhydric acid gas passed into the liquid until the whole of the cobalt was converted into cobalti-cyanide of barium, $\text{Co}_2\text{Cy}_{12}\text{Ba}_3$. The solution of this salt was then boiled with mercuric oxide to separate the nickel present, as NiCy_4 Ba, as well as traces of iron and manganese. The mercury was then removed from the filtrate by sulphydric acid gas, and the solution of cobalti-cyanide barium regarded as chemically pure. The methods which I adopted to determine the atomic weight of cobalt do not differ in principle from those of Weselsky and Sommaruga. I first formed cobalti-cyanides of alkaloids having high atomic weights and forming highly crystalline and perfectly definite double cyanides. I then determined the water of crystallization in these salts directly, and afterwards the percentage of cobalt in each. This last was effected by first carefully heating the salt in a platinum crucible by means of a ring-burner, and afterwards burning off the carbon, first in air and then in oxygen. Finally the cobalt was reduced to metal by a current of pure hydrogen, and weighed. In this manner but two weighings were necessary. In another series of experiments, I determined the amount of metallic cobalt in weighed quantities of chloride of purpureocobalt by igniting the salt in a current of pure hydrogen gas. To effect the reduction without loss, I employed an arrangement due to Dr. Gibbs, and consisting of a small thin disk of porous earthenware. The chloride of purpureocobalt was placed in a porcelain crucible and the disk of earthenware supported above it by the walls of the crucible. The hydrogen was introduced by a tube passing into the bored cover and the crucible was then carefully heated from above. In this manner the gas diffused through the porous septum, which in turn served to prevent the escape of any particles of solid substance. The reduction was absolutely complete, and the metal did not oxidize after slowly cooling in an atmosphere of hydrogen. In the analyses made in this manner, also, but two weighings were necessary.

In my first series of experiments I employed only the cobalticyanides of brucine and strychnine, the corresponding salts of morphine, narcotine, chinine and cinchonine having been found difficult to prepare in a state of purity by recrystallization. The brucine and strychnine salts were prepared by decomposing the sulphates of these bases with cobalti-cyanide of barium, and repeatedly recrystallizing the salts formed. The brucine salt crystallized in beautiful white, barb-shaped crystals with a high luster. It was but slightly soluble in cold water, and crystallized with remarkable facility. The strychnine salt was in beautiful, nearly colorless needles, and like the brucine salt crystallized almost completely from its solution on cooling. Six analyses were made with each of these salts.

Of the strychnine salt—

0·7084 gr. dried at 115°C. lost 0·0392 gr. of water = 5·53 p. c. The formula, $\text{Co}_2\text{Cy}_{12}(\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2)_6\text{H}_6+8\text{OH}_2$, requires 5·57 p. c. water of crystallization.

The following are the results of my determinations of the amount of cobalt in this salt:

No.	Salt taken.	Cobalt.	Cobalt, p. c.	At. weight.
1.	0·4255 gr.	0·0195 gr.	4·583	59·22
2.	0·4025 "	0·0185 "	4·596	59·36
3.	0·3733 "	0·0170 "	4·554	58·83
4.	0·4535 "	0·0207 "	4·564	58·96
5.	0·2753 "	0·0126 "	4·577	59·14
6.	0·1429 "	0·0065 "	4·549	58·76
		Mean,	4·5705	59·05

The probable error of the mean is ±0·012, and the atomic weight of cobalt 59·05, with a probable error of ±·156. In the case of the brucine salt, three determinations of the water of crystallization were made.

0·4097 gr.	gave	0·0465 gr.	water at	117° C.	=	11·35 p. c.
0·3951 gr.	"	0·0453 gr.	"	119° C.	=	11·46 p. c.
0·6653 gr.	"	0·0752 gr.	"	128° C.	=	11·30 p. c.

The mean of these three determinations is 11·37 p. c.

The formula $\text{Co}_2\text{Cy}_{12}(\text{C}_{23}\text{H}_{26}\text{N}_2\text{O}_4)_6\text{H}_6+20\text{OH}_2$ requires 11·39 p. c. water of crystallization.

The results of my determinations of the amount of metal in this salt are as follows:

	Salt taken.	Cobalt.	Cobalt, p. c.	At. weight.
1.	0·4097 gr.	0·0154 gr.	3·759	59·41
2.	0·3951 "	0·0147 "	3·720	58·76
3.	0·5456 "	0·0204 "	3·739	59·08
4.	0·4402 "	0·0165 "	3·748	59·22
5.	0·4644 "	0·0174 "	3·747	59·21
6.	0·4027 "	0·0151 "	3·749	59·24
		Mean,	3·7437	59·15

The probable error of the mean is here ±0·0088, and the atomic weight of cobalt 59·15, with a probable error of ±·146.

The method of analyzing the chloride of purpureocobalt has already been described. The results of my analyses are as follows:

No.	Salt taken.	Cobalt.	Cobalt, p. c.	At. weight.
1.	0·9472 gr.	0·2233 gr.	23·575	59·07
2.	0·8903 "	0·2100 "	23·587	59·11
3.	0·6084 "	0·1435 "	23·586	59·11
4.	0·6561 "	0·1547 "	23·579	59·08
5.	0·6988 "	0·1647 "	23·569	59·05
6.	0·7010 "	0·1653 "	23·581	59·09
		Mean,	23·5795	59·09

The probable error of the mean is here ±0·004, and the calculated atomic weight 59·09, with a probable error of ±·0146.

The mean of my eighteen determinations of the atomic weight of cobalt is 59·10. For the sake of comparison I give here the results obtained by other observers, in tabular form, reduced to the modern scale of atomic weights:

Rothhoff,	59·10	Dumas,	59·08	Winkler,	58·99
Schneider,	60·00	Russell,	58·74	Weselsky,	58·96
Marignac,	{ 58·84 to 59·02 58·72 to 58·84	Sommaruga,	59·93	Lee,	59·10

Nickel.—The atomic weight of nickel was also first determined by Rothhoff* in 1826, by determining the amount of chlorine in a weighed quantity of nickelous chloride. A single experiment gave for the equivalent 29·60, a number which is probably too high, in consequence of the imperfection of the processes known at that time for the separation of nickel from cobalt. Erdmann and Marchand took up the subject in 1852.† Nickelous oxide prepared by various processes was reduced in a current of hydrogen and the metal weighed. No data are given, but the authors state that their results varied between 29·1 and 29·3, and that they consider the lower number more probably correct.

Schneider,‡ in 1857, also determined the atomic weight of nickel. Pure nickelous oxalate was burnt with cupric oxide to determine the oxalic acid, while the amount of metallic nickel was obtained by reducing the oxide with pure hydrogen. In this manner Schneider obtained as the mean of four analyses the number 29·02.

Marignac,§ in 1857, determined the atomic weight of nickel by methods precisely similar to those employed by him in the

* Pogg. Ann., vol. viii, p. 184.
† Ann. der Pharmacie, lxxxii p. 76.
‡ Pogg. Ann., ci, p. 387.
§ Bibliothique Universelle de Geneve, Nouvelle Series, vol. i, p. 373.

case of cobalt already cited. His analyses of the sulphate of nickel gave results varying from 29·2 to 29·5, while those of the chloride gave results varying between 29·4 and 29·64. Marignac does not give his method of obtaining pure salts of nickel.

The subject was next investigated by Dumas,* who determined the quantity of chlorine in nickelous chloride, and obtained for the equivalent of nickel as a mean of five analyses the number 29·514. The author does not give the process by which the nickel was obtained free from cobalt.

Russell† took up the subject of the atomic weight of nickel, together with that of cobalt, in 1863. Pure nickelous oxide was first ignited in a current of carbonic di-oxide, and afterward in pure hydrogen. His results were as follows:

	Metal.
1st specimen, mean of 3 determinations 100 parts of oxide, gave	78·596 Ni.
2. " " " " "	78·584 "
3. " " " " "	78·598 "
4.‡ " " " " "	78·592 "

The mean of all the determinations gave for the quantity of nickel in 100 parts of the oxide 78·5925, and for the atomic weight of nickel 58·74.

In 1866, Sommaruga§ determined the atomic weight of nickel by ascertaining the quantity of sulphuric acid in pure crystallized double sulphate of nickel and potassium. The mean of six analyses gave for the equivalent of nickel the number 29·013, with a probable error of ±0·079.

Winkler,‖ in 1867, employed the method of reduction already described. The mean of four analyses gave for the equivalent 29·527, with a probable error of ±0·056.

With these preliminary statements I pass to an account of my own methods and results. Metallic nickel of commerce was dissolved in nitro-sulphuric acid, and the nitric acid expelled by heat. The sulphate was then dissolved in water and the traces of copper and arsenic removed by a long continued current of sulphydric acid gas. The iron in the filtrate was then oxydized by means of bromine, and precipitated by agitation with Ba Co_3. The cobalt was removed by potassic nitrite and the nickelous sulphate then converted into nickel-cyanide of potassium, which was recrystallized. This salt contained only a trace of cobalt, after four crystallizations. To determine the atomic weight of nickel I adopted the method already employed to determine that of cobalt. I first formed the double cyanides of nickel with brucine and strychnine, and then determined, first

* Ann. de Chimie et de Physique, 3d series, vol. lv, p. 148.
† Ann. der Pharmacie, vol. cxxvi, p. 322 to 336.
‡ Second purification.
§ Sitzungsberichte der Weinen Akad., vol. liv, p. 50.
‖ Zeitschrift für Analyt. Chemie, 1867, p. 18.

the quantity of water in each of these salts, and afterward the percentage of metallic nickel. This last determination was effected by first carefully heating the salt in a platinum crucible, employing the ring-burner of Dr. Gibbs so as to apply the heat at the rim of the crucible first, and afterward in successive zones until the bottom of the crucible was reached. The remaining carbon was then burned off in a current of pure oxygen, and the oxide of nickel finally reduced by igniting it in carefully purified hydrogen. The double cyanides of nickel, brucine and strychnine were prepared by double decomposition, the salts being but slightly soluble in cold water. They were then repeatedly recrystallized, and when tested by the spectroscope were found to be absolutely free from potassium. All of these salts crystallized in very pale yellow needles.

My analyses of the brucine salt led to the following results:

0·4496 gr. dried at 120° C. lost 0·0258 gr. ΘH_2=5·738 p. c. water.

The formula $Ni_3Cy_{12}(C_{23}H_{26}N_2O_4)_6H_6+10\Theta H_2$, requires 5·929 p. c.

No.	Salt taken.	Nickel.	Nickel, p. c.	At. weight.
1.	0·3966	0·0227	5·724	57·92
2.	0·5638	0·0323	5·729	57·98
3.	0·4000	0·0230	5·750	58·20
4.	0·3131	0·01795	5·733	58·02
5.	0·4412	0·0252	5·712	57·79
6.	0·4346	0·0249	5·729	57·98
		Mean,	5·7295	57·98

The probable error of the mean percentage of nickel is ±0·008, and the atomic weight of nickel 57·98, with a probable error of ±0·089.

Six analyses of the strychnine salt were then made:

0·3399 gr. dried at 112° C. lost 0·0178 gr. water = 5·24 p. c.

The formula $Ni_3Cy_{12}(C_{21}H_{22}N_2O_2)_6H_6+8\Theta H_2$, requires 5·45 p. c.

No.	Salt taken.	Nickel.	Nickel, p. c.	At. weight.
1.	0·5358	0·0354	6·607	58·15
2.	0·5489	0·0363	6·613	58·21
3.	0·3551	0·0234	6·589	57·98
4.	0·4495	0·0297	6·607	58·15
5.	0·2530	0·0166	6·561	57·72
6.	0·1956	0·0129	6·595	58·04
		Mean,	6·595	58·04

The probable error of the mean percentage of nickel is ±0·013, and the atomic weight 58·038, with a probable error of ±0·119.

The mean of all my determinations of the atomic weight of

nickel is 58·01. The following table gives all the determinations made:

Rothhoff,	59·20	Dumas,	59·028
Erdmann and Marchand,	58·20 to 58·60	Russell,	58·74
		Sommaruga,	58·026
Schneider,	58·04	Winkler,	59·054
Marignac,	58·40 to 59	Lee,	58·01

In conclusion, my thanks are due to Dr. Gibbs for the selection of the subject of my work, and for his advice during the course of my investigation.

Cambridge, May, 1871.

Art. X.—*Note on the Spectrum of the Corona*; by Prof. C. A. Young.

In an article upon the Solar Corona, which appeared in the May number of this Journal, I wrote, "very perplexing also is the fact that the faint continuous spectrum, which must be in part produced by this polarized component of the corona's light, shows no discoverable traces of the dark lines of the ordinary sunlight-spectrum. Probably they exist, but are in some way masked so that they are not easily detected."

On further reflection, however, I believe the matter is readily explained. and that on the other hand it would have been remarkable if we had been able to bring out the Fraunhofer lines.

The truth is that the reflected photospheric sunlight forms only one small fraction of the total coronal radiance, the other constituents of which so far preponderate that it becomes very difficult to detect in the general spectrum the characteristics of this reflected light.

The spectrum of the corona is, in all probability, composed of at least *four* superposed elements.

1st. A continuous spectrum, without lines either bright or dark, due to incandescent dust—that is, to particles of solid or liquid meteoric matter near the sun. For although I am not able to admit with Mr. Proctor that the whole explanation of the corona is involved in the presence of such meteoric particles, yet it cannot be doubted that they are very numerous; and any that may come within 250,000 miles of the solar surface must become incandescent and give such a spectrum as described.

2nd. A true gaseous spectrum of the second order, consisting, like all such spectra, of a more or less bright continuous background with well marked maxima or bright lines. In this case one bright line (1474) certainly exists, and perhaps several. So

far as the spectroscopic evidence goes this gas may be simply the vapor of the meteoric dust above alluded to, liberated by the heat of the sun, as when powdered sodium is dropped into an alcohol flame; or it may be disengaged for the instant from the same particles by electric discharges between them, as when the bright lines of metallic vapor appear in the spectrum of the spark produced by an induction coil. But in my previous article I have stated reasons for believing that the gas is of a more permanent character—a solar atmosphere through and in which the meteoric particles move as foreign bodies.

3rd. A true sunlight-spectrum (with its dark lines) formed by photospheric light reflected from the solar atmosphere and meteoric dust. To this reflected sunlight undoubtedly is due most of the polarization, and were it possible to separate the polarized component of the coronal light from the rest, we might perhaps hope to find in it traces of the Fraunhofer lines. It is by no means impossible, however, that the spectroscopic character of reflected light may undergo some change, such as a partial obliteration or degradation of its lines, when the reflecting particles are sufficiently minute—small, that is as compared with the dimensions of a wave of light, so that they do not merely reflect the undulation at their surfaces, but themselves enter into motion bodily. Experiments upon the spectrum of the light emitted by one of the so-called actinic clouds would, perhaps, clear up the subject.

4th. Another component spectrum is due to the light reflected from the particles of our own atmosphere. This is a mixture of the three already named, with the addition of the chromosphere spectrum; for while at the middle of an eclipse the air is wholly shielded from photospheric sunlight, it is of course exposed to illumination from the prominences and upper portions of the chromosphere. This light from the terrestrial atmosphere, like that reflected by particles near the sun, is evidently partially polarized in radial planes.

And if there is between us and the moon, at the moment of eclipse, any cloud of cosmical dust, the light reflected by this would come in as a *fifth* element. It would, however, only differ from that reflected by our own atmosphere by including a greater or less modicum of photospheric sunlight.

Furthermore, in instruments like those employed by Messrs. Abbay and Pye, the chromosphere spectrum overlies that of the corona, and increases the complication.

It would seem, therefore, that only a small percentage of the light which falls upon the slit of the spectroscope during a total eclipse contains the Fraunhofer lines at all, and it ought not to be considered strange that they are not readily observed.

In the same article I have stated that the photographs, taken by the American party in Spain, appear to differ essentially from those obtained by Mr. Brothers, in Sicily. This statement was based upon a comparison instituted by Mr. Lockyer, Professor Winlock and myself, between a copy of the American photograph and a drawing* of Mr. Brothers' photograph, which (drawing) he had himself sent to Mr. Lockyer.

There was a general and even striking agreement between the two in respect to the position of the 'gaps' and the distribution of the luminosity, yet there certainly were, as Mr. L. pointed out, very noticeable and important differences, and of a character to suggest that the extensive outside radiance might probably be of a less permanent character than the leucosphere, and of a different origin.

But I understand that when photographic copies of Mr. Brothers' and the American negatives are made to a common scale then these differences disappear and the agreement becomes nearly absolute in respect to all essential particulars. If this be so, it certainly bears very strongly in favor of those theories which assign a purely solar origin to the whole phenomenon.

Dartmouth College, May 10, 1871.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Note on Para-sulphobenzoic Acid;* by Ira Remsen, M.D., Ph.D., Assistant in the University laboratory, Tübingen, Germany. —In my former note. (volume i, page 462), I stated that when ordinary sulphobenzoate of potassium is fused with hydrate of potassium, a mixture of oxybenzoïc and para-oxybenzoïc acids is always formed, instead of pure oxybenzoïc acid, as was up to that time supposed. From this fact I concluded that two salts must be contained in ordinary sulphobenzoate of potassium.

In order to decide this point, I separated the free acid from the same potassium salt that had been made use of for the first experiment described in the note mentioned. This was accomplished by decomposing the salt with the necessary quantity of sulphuric acid, evaporating to dryness and extracting with alcohol. With the acid mixture obtained I prepared an acid barium salt, by neutralizing with carbonate of barium, dividing the solution into two equal parts, precipitating the barium from the one exactly with sulphuric acid and then mixing the two again. On evaporating this solution, it became filled with beautiful needles on cooling.

* I am not sure but we had a photographic copy of Mr. Brothers' drawing instead of the drawing itself; but we did not have a photographic copy of the original negative. No such copies had then been made.

These did not possess the least resemblance to the crystals of the known acid barium salt of sulphobenzoïc acid. They were filtered off and recrystallized. Their form was not changed by this process. The salt was now repeatedly recrystallized from water and each time it separated in needles which became longer and more beautiful, the finer they became. It was dried by being allowed to stand for some time over sulphuric acid, and then subjected to analysis. It contained water of crystallization, which was not driven off at a temperature lower than 250–260°. The salt has the formula $(C_{14}H_{10}S_2O_{10})$ Ba+$3H_2O$. The analyses gave the following numbers:

Found,	H_2O	8·95 pr. ct. and 9·38 pr. ct.
	Ba	25·34 pr. ct. and 25·38 pr. ct.
Calculated,	H_2O	9·10 pr. ct. Ba 25·41 pr. ct.

The mother liquor from these needles was now evaporated, and in this way a salt of entirely different appearance was obtained. After being recrystallized it formed very regular, beautiful monoclinic crystals, which resembled the known acid sulphobenzoate of barium in every respect. This salt was also analyzed and the same formula found for it as for the needles. The water of crystallization escaped at 200°.

Found,	H_2O	9·34 pr. ct.	Ba	25·56 pr. ct.
Calculated,	H_2O	9·10 pr. ct.	Ba	25·41 pr. ct.

Although the decided difference in the solubility of the salts and in their crystalline form, which constantly presented itself, made it exceedingly improbable, it was still possible that two different conditions of the same salt were here under observation and not two isomeric salts, particularly as the analyses had shown them to contain the same number of molecules of water of crystallization. There was hence still an experiment necessary to prove the isomerism. The two barium salts were converted into the neutral potassium salts and these melted into hydrate of potassium.

The potassium salt that was obtained from the needles, yielded perfectly *pure para-oxybenzoïc acid* as the only product of the reaction. The acid showed all the characteristic signs of para-oxybenzoïc acid. The crystalline form was the same. It contained water of crystallization, which was given off at 100°. Its melting point was exactly 210°. The crystals were very regularly formed and possessed a mother-of-pearl luster.

The nature of the salt that crystallizes in needles is thus explained. It is a salt of *para-sulphobenzoïc acid.*

Acid para-sulphobenzoate of Barium is difficultly soluble in hot water (much more so than the known corresponding salt of metasulphobenzoïc acid), and almost insoluble in cold water. When pure it crystallizes from a hot solution during the process of filtering. If it be now redissolved and allowed to stand quietly, beautiful flattened needles are found in the solution, which fill the entire vessel from top to bottom.

The *neutral potassium salt* is very easily soluble in hot, as well as in cold water, and crystallizes from its concentrated solution in needles. Owing to a want of material it was not analyzed.

The potassium salt, obtained from the monoclinic barium salt, on being fused with hydrate of potassium, yielded only oxybenzoic acid, as anticipated.

The principal product of the action of sulphuric acid on benzoic acid is then meta-sulphobenzoïc* acid, while at the same time there is produced in all cases a certain amount of the para-acid. As may be seen from the experiments described, there are conditions which are just as favorable for the production of the para-acid as for that of the meta-acid. I have as yet however but once succeeded in meeting these conditions, notwithstanding the fact that a large number of experiments were made with this object. I first repeated the preparation of sulphobenzoïc acid, retaining as closely as possible the conditions under which the first preparation took place; the chief product was not the para- but the meta-acid. Owing to this want of success I have not been able to study the properties of para-sulphobenzoïc acid better. Although its formation was proven under all and the most varied circumstances, the quantity was too small and its separation too difficult to admit of isolation. When present in larger quantity than the meta-acid, as was the case in the experiment mentioned above, the separation by means of the acid barium salts is very simple. If, however, the meta-salt predominates, on evaporating the mother liquor from the first crystallization both salts crystallize out together, forming crystals entirely different from either of the pure salts, and these may be recrystallized repeatedly without effecting their separation into their components.

I am continuing my experiments with the object of discovering the conditions of the formation of the para-acid. At the same time I shall attempt to prepare the same acid by the oxidation of para-sulphotoluolic acid, and will probably soon be able to report on its properties more exhaustively.

Tübingen, May 16.

II. Geology and Natural History.

1. *Mineral silicates in Fossils;* by T. Sterry Hunt. (Communicated).—Since the discovery of a mineral silicate injecting fossils in a paleozoic limestone from New Brunswick, Dr. Dawson has examined a great many limestones from different localities, to obtain further facts which might serve to throw light on the history of Eozoon. A remarkable example of a similar phenomenon has been found by him in a limestone from the collection of the late Dr. Holmer, marked Llangedoe (Wales), and preserved in the Museum of McGill College. The rock is granular crystalline, and made up of organic remains, chiefly fragmentary, for the most part infiltrated by a silicate similar to that from Pole Hill, New Brunswick. The only perfect fossil detected by Dr. Dawson

* Meta = 1·3.

is a small coral-like body referable to the genus Verticillopora, an Upper Silurian form. The limestone includes besides, however, joints and plates of crinoids, small spiral gasteropod shells, with fragments of brachiopods and of a sponge-like organism with square meshes. All of these fossils are more or less penetrated with a greenish silicate, which fills the cavities of the gasteropods, the central canal of the crinoids and the pores of the Verticillopora. It has also replaced or filled the spongy fibers and injected the minute cells of some of the crinoidal fragments, though many of these are solid and calcareous throughout, in which respect the specimen differs from that from New Brunswick, described in this Journal for May, 1871 (p. 379), where the infiltration of the crinoidal remains is much more complete and perfect. Dr. Dawson, to whom we owe these observations, supposes that in both cases the infiltration took place while the remains were still recent.

Decalcified surfaces of the limestone show similar appearances to those presented by the New Brunswick specimens; the casts of small shells like Murschisonia, two millimeters in length, are in some cases perfect. The limestone is nearly pure, with the exception of a little fine yellow ochreous mud, which is insoluble in dilute hydrochloric acid, and remains suspended in the solution, but is easily separated by washing from the pale greenish-gray silicate. This equals about three per cent of the weight of the limestone. When ignited in the air it assumes a bright fawn color, and under the microscope then contrasts strongly with the colorless grains of quartz or other hard siliceous minerals with which it is mixed. Its analysis by Mr. Sterry Hunt in the manner described for the New Brunswick mineral shows that it scarcely differs from this except in being more hydrated and almost identical with jollyte. It gave, after deducting 21·0 per cent of insoluble sand, the following composition for one hundred parts: Silica 35·32, alumina 22·66, protoxide of iron 21·42, magnesia 6·98, potash 1·49, soda 0·67, water 11·46 = 100·00.

2. *Mastodon remains in Central New York;* by B. G. WILDER. (Communicated.)—Five teeth and many bones and fragments of the Mastodon have been discovered in a deposit of modified drift near Ithaca, New York, and placed in the Museum of Cornell University. Many more remains will doubtless be obtained, as the teeth already indicate the existence of two or more individuals; little hope is entertained, however, of finding a perfect skeleton.

3. *Fucoids in the Coal measures of Iowa.*—Prof. WHITE, in his "Geology of Iowa" (vol. i, p. 241), notices the occurrence of forms identical with or allied to *Caulerpites marginatus*, in the Lower Coal-measures of Wapello county, Iowa, and of other forms, more or less indistinct, in the higher portions of the series (see p. 281, l. 4). F. H. B.

4. *Phosphatic Sand in South Carolina.*—Prof. C. U. SHEPARD has described a deposit of sand over the phosphatic nodular bed of Stone River, which has resulted from the wear of the latter by the waters, and in some places is at least six feet thick. A portion

of it, after drying in the air, was found to contain 27 p. c. of the phosphate of lime, with 63·5 of fine (nearly impalpable) and coarse sand, 3·0 of carbonate and sulphate of lime, 6·5 moisture and organic matter. By agitation in water the lighter flocculent siliceous part may be floated off, and the phosphatic portion thus concentrated to 37 per cent of the remainder. Prof. Shepard observes that this sand deposit appears to be very extensive. He suggests that it may require, after washing, to be treated with sulphuric acid, at the rate perhaps of 100 pounds to the ton; the phosphoric acid would thus be rendered partially soluble. He observes that the phosphate is in too impure a state for railroad exportation, but "for use on lands contiguous to water its future value cannot be doubted."—*Rural Carolinian*, May, 1871.

5. COUES *on Antero-posterior Symmetry.**—That the anterior and posterior limbs of vertebrates are homologous is now admitted by all; but the majority of anatomists hold that they are to be compared as *parallel* parts, while a few † believe that they should be compared as symmetrical or antagonistic parts, as are the right and left sides; the former relation may be called "Syntropy," the latter, "Antitropy;" and the advocates of these ideas, "Syntropists" and "Antitropists" respectively.

The latter have lately been joined by a vigorous ally, to whose work attention has already been called ;‡ and the accession is the more opportune because some recent English writers ‖ upon intermembral homologies have regarded the question as already decided in favor of Syntropy, and in the determination of muscular homologies they take for granted that pollex (thumb) is the homologue of primus (great toe), whereas the antitropists above mentioned regard the relation between them as one of analogy only, the pollex being the true homologue of quintus (little toe) and the primus of minimus (little finger). The propriety of this view is admirably presented by Wyman,§ together with the obvious objections thereto and the grounds upon which these objections may be removed.¶

* Antero-posterior Symmetry with special reference to the Muscles of the Limbs; by ELLIOTT COUES, M.D., Assist. Surg. U. S. A.; New York Medical Record, July, 1870, et seq., pp. 149–152, 193–195, 222–224, 272–274, 297–299, 370–372, 390–391, 438–440.

† Agassiz, Dana, Foltz, Wyman and the writer.

‡ American Naturalist. May, 1871.

‖ Flower, Humphrey, Mivart, Rolleston.

§ Symmetry and Homology in Limbs, Proc. Bost. Soc. Nat. Hist., June 5th, 1867.

¶ The general and special questions here involved have been discussed by me at several times since they were first suggested to me by a verbal communication of Prof. Wyman to the Bost. Soc. Nat. Hist., June 6th, 1860: and I shall shortly publish a somewhat extended paper upon the subject, (Proc. Bost. Soc. Nat. Hist., Apr. 19th, 1871) containing the following:

1. An historical sketch of the question. 2. A revision of the nomenclature of parts. 3. A revision of the nomenclature of ideas. 4. Evidence as to the morphical inconsequence of numerical composition. 5. Indication of general problems. 6. Indication of special problems. 7. Chronological list of 76 special works upon intermembral homologies. 8. Alphabetical list of 227 collateral works.

Dr. Coues follows closely in the footsteps of his distinguished predecessor, "not blindly, but unable not to see the validity of his arguments," (195) and therefore, with a few minor differences or doubts respecting details, adopts the osseous homologies of Wyman as the basis for the determination of "muscular correspondences." In respect to these latter, although Dr. Coues is led to differ materially upon some points from my own previous conclusions, yet he has generally shown such good reason therefor, that my praise of this part of his work is unqualified, and I am anxious to go over the whole ground anew in the light of his able discussion. To consider his arguments and conclusions in detail would require a paper equal in length to his own, and I reserve this task for some future occasion when his later and most instructive paper upon the myology of Ornithorhynchus can be included; the general and special problems involved are discussed at some length in the paper already referred to.

But while ready to express the most hearty admiration of Dr. Coues' labors, and confidence in his ability to even surpass them in future, I am forced to criticise some of his methods. In the first place he has "no acknowledgments to make" excepting to three* (149), and therefore, whatever satisfaction may be derived from having so taken up the subject fresh, he has also lost the benefit of the checks which an acquaintance with many and different views exerts upon the tendency to the exclusive adoption of any one; and he has thus, as it seems to me, been led to adopt a faulty method from each of his predecessors.

He has unconsciously imitated Owen in the use of many different and often ponderous expressions for the same idea "in order to avoid monotony,"† whereas, in homologies, as in mathematics, each object and idea should be known by a single term, and by that alone; since, of all the natural sciences, this demands the closest attention, and the absence of all secondary considerations.

Dr. Coues has accepted unquestioned the view of the normal position of the membra for comparison which was first proposed by Wyman, and adopted by Foltz, Folsom and myself; this view is based upon the proposition of Wyman, (op. cit. 265) that "the knees and elbows in all animals are bent so as to form angles pointing in opposite directions;" if we except the fishes, this generalization is correct, *provided* the membra are placed in the position they have with most quadrupeds; but Goodsir, Humphrey, Huxley and Wyman himself have shown that this is not their *primary* position, and it is quite possible that Wyman and Coues might have followed Huxley in denying that it is their *normal* position, had they read his paper; the desire to admit this radical change in my own views upon this point was one of the chief motives for the preparation of the paper already referred to, since do-

* Owen, Wyman and the writer.

† As for instance, "*two-jointed* thumb" is coupled with "*biarticulated* great toe," p. 193; and in a few cases there is tautology, as in "morphologically homologous" and "teleologically analogous," p. 194.

ing so involves a concession, though not essential one to the idea of syntropy.

Finally, Dr. Coues has accepted from the writer a nomenclature of ideas, (Antitypy, &c.,) which was itself based upon Owenian phraseology, which was in no way expressive of the ideas designated thereby, and which I now propose to discard for a more significant nomenclature derived from a term (Antitropy) already in use. I have commented upon some of Dr. Coues' methods the more freely, in part because of my unqualified admiration of his real individual work, but chiefly because as regards the use of many and long words, and the acceptance of the peculiar views of single authors, my own sins have been more and greater than his can ever be. B. G. W.

6. *Supplement to "Annélides chétopodes du Golfe de Naples."* —Claparède has published a Supplement to the Annelids of the Gulf of Naples especially interesting for its complete observations on the singular phenomena of reproduction of the Nereids, which were barely suspected at the time the principal part of his monograph appeared.

Malmgren in 1864 was first led to suspect a genetic relation between Nereis and Heteronereis, from a comparison of *Nereis pelasgica* and *Heteronereis grandifolia*, showing nearly an absolute identity, with the exception of the peculiar foliaceous appendages and bristles of the posterior part and other minor characters only developed at the period of sexual maturity. This led him to look upon certain species of Nereis as the agamous stock of sexual individuals appearing as Heteronereis. Subsequently having found eggs in this presumed agamous Heteronereis stock, he came to the conclusion that, although all the species of Iphinereis and Heteronereis were only sexual forms in series of generations still unknown, yet that at some time, during sexual maturity a stage of one of the polymorphous species of Nereis assumes the characters of Heteronereis, to lose them subsequently and return to its agamous stage. Malmgren accounted for the genetic relations by an alternate generation at first, and afterwards by a metamorphosis; both of which hypotheses Claparède shows conclusively are justifiable. Ehlers has shown that a large number of species of Heteronereis were only sexual forms of previously known species of Nereis, and interprets these facts in favor of a metamorphosis of Nereis into Heteronereis.

This was the condition of the problem when Claparède resumed the subject and showed conclusively (from the study of living Annelids) that there is a genetic relation between Nereis and Heteronereis, but he shows as conclusively that all Nereids do not have their Heteronereis form, as had been taken for granted by Ehlers, and that there is in the Annelids of this family a polymorphism almost without parallel in the animal kingdom. Taking the species which he has most carefully studied (*Nereis* (*Leontis*) *Dumerillii*) we have first a sexual form as Nereis, two sexual forms as Heteronereis, and a fourth hemaphrodite form discovered

by Mecznikow. Large full grown specimens of *Nereis Dumerilii* are all transformed into Heteronereis, while the small diminutive individuals alone become matured as Nereis. Of the two sexual forms of Heteronereis one is small, extremely active, swimming freely about and eminently pelasgic, the other is sluggish, remaining more or less stationary at the bottom of the sea. The variations in size of individuals becoming sexual as Nereis or changing into Heteronereis are considerable, and it may be that a species can arrive at maturity in all stages of growth, may subsequently lose all traces of its sexuality, increase in size and in number of segments, to take on late again sexual characters and be transformed into Heteronereis. Absolute certainty of the sequence of these changes can only be obtained by tracing them in an aquarium.

This Supplement is illustrated by fourteen excellent plates, completing data left more or less imperfect in the first part. There are excellent observations, and figures, on the eyes of Alciopidæ, confirmatory of former papers by Krohn and Leydig on the same subject, adding many new points of considerable physiological importance. In the preface, Claparède promises us an extended memoir on the histology of Annelids (for which he has many thousand admirable preparations), he calls attention to the restoration of many specific names first introduced by Delle Chiaje which have usually been neglected. As a mark of his appreciation of Delle Chiaje's work he fittingly dedicates to him the closing chapters of this excellent contribution to the fauna of the Bay, where he worked so long and so successfully. A. AG.

7. *Diapensiaceæ.*—To the account of this small group of plants, as given in a paper entitled: "*Reconstruction of the order Diapensiaceæ*, presented to the American Academy in June, 1870, and issued at the close of the year, Dr. Maximowicz, in the ninth decade of his *Mélanges Biologiques*, published by the St. Petersburgh Academy this spring, has added some interesting comments and observations. He first remarks that he not only approves of the association of *Schizocodon* and *Galax* with *Diapensia*, but had himself suggested it in the year 1867, in a letter to Prof. Bunge, who had responded in favor of the suggestion. He also now concludes that both *Shortia* and *Shizocodon* are probably to be maintained as genera; the former including *Schizocodon uniflorus* as a second species is most likely distinct from the Alleghanian plant and clearly different from *Schizocodon soldanelloides*. This opinion is grounded mainly upon a drawing, which apparently represents the plant in question, in a Japanese work in his possession, and which exhibits the corolla, this, curiously enough, being wanting in the about 30 known specimens of the Japanese plant, as well as in the solitary American specimen. The closely adherent testa of the seed and the slender style are the most marked characters.

In the same publication Dr. Maximowicz characterizes a remarkable new Japanese genus, *Ellisiophyllum* (so named from the like-

ness of the leaves to those of *Ellisia*) which is intermediate between *Hydrophyllacea* and *Polomoniaceæ*. The habit, dicarpillary ovary hirsute at apex, and imbricated petals are suggestive of the former order; but the undivided style, central placentation, and especially the mucilaginous seed-coat, place it rather in the latter.

Dr. Maximowicz, moreover, has ascertained that our *Euodia ramiflora* is Thunberg's *Orixa Japonica*, of which only male flowers were known; and he restores that genus, referring it to the neighborhood of *Euodia*. A. G.

8. *Form and Sculpture of Seeds.*—Prof. Lange of Copenhagen has published, in *Botanisk Tidsskrift*, 1870 (in Danish) an interesting paper upon this subject, which, as botanists know, often furnishes excellent characters to distinguish otherwise similar species. He treats here of *Pyrolaceæ*, *Droseraceæ*, *Cerastium*, and especially of *Pedicularis*, with illustrations. In two plates, filled with beautiful colored figures, the seeds of 25 species of *Pedicularis* are strikingly depicted. A. G.

9. *Hypocotyledonary Gemmation* is of uncommon occurrence. My attention has been called, by Mr. Guerineau, the gardener of the Cambridge Botanic Garden, to a remarkable instance, which occurs in all our seedlings of *Delphinium nudicaule*, the unique red or red-and-yellow-flowered species of California. As this species is now in European cultivation, and a probable variety of it, *D. Cardinale* was raised and figured in England several years ago, the peculiarity in question is likely to have been noted; but I have seen no account of it. In germination, the slender radicle elevates a pair of well-formed ovate cotyledons in the usual way. These acquire full development; but no plumule appears between them; consequently the primary axis is here arrested. Soon a nassiform thickening is formed underground at the junction of the lower end of the radicle with the true root: from this is produced a slender-petaled 3-lobed leaf, which comes up by the side of the primary plantlet; soon a second leaf appears, and so on, setting up the permanent axis of the plant from a bud which thus originates from the very base of a well-developed radicle, if not from the root itself. A. G.

III. ASTRONOMY.

1. *A remarkable Meteor;* by R. H. THURSTON, U. S. N. (Communicated.)—While standing on the deck of the steamer "Electra," last evening, *en route* from Providence to New York, I was startled by a sudden flash of bright blue light which illuminated the whole heavens and was instantaneously succeeded by an equally intense red flash which again gave place to blue. Turning suddenly, I saw a falling meteor, which was, so far as my knowledge extends, unique.

It exhibited a nucleus of blue, with a long flame-like train also blue in color except on the south side where a portion, equal to perhaps one-third of the whole, was of a brilliant red.

The height of the meteor, at disappearance, was about 29° above the horizon, its bearing nearly due east from Watch Hill Light, and the time, at that place, not far from 9:15 P. M. It was about 25′ in length, and 5′ in width, moving directly downward.

Stevens' Institute of Technology, Hoboken, N. J., June 15th, 1871.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the influence of a covering of Snow on Climate;* by A. WOJEIKOF, Member of the Imp. Russ. Geogr. Society. (Communicated).—The influence of a layer of snow, resting on the earth's surface in the colder portions of the earth during winter, has, to my knowledge, never been considered in its general bearing on the climate and the conditions of the population living in these countries.

The first and most apparent influence of snow is the protection it affords to our crops from the cold of winter. Where the snow-mantle appears regularly, winter-crops are always sure, be the cold ever so intense. In the steppes of south and east Russia, where little snow falls in winter, and this small quantity is often blown away by the strong winds, winter crops are scarcely attempted at all. On the northern coasts of the Black Sea, summer wheat and Indian corn are very good, but winter wheat is a precarious crop, while to the north, in Podolia, it is the principal crop. There the forests afford a protection against the wind, the snow falls more copiously and cannot be blown away.

As a bad conductor of heat, the snow isolates the warmer soil from the cold air above, and there is no doubt that it renders also the winter cold more intense, as the air cannot receive heat from below. In countries where the snow-covering is not permanent, as Western Europe, this influence of snow is well known, and people expect great cold where a layer of snow has fallen and the sky clears. In countries where snow usually lies the whole winter, as Russia and the northern parts of America, this is not generally understood, and in Russia people say it is colder without snow than with it. This feeling is quite natural. The first frosts of autumn are more severely felt because the human body is not accustomed to them, and also because the air is drier than with snow, and a cold, dry wind is more severely felt than a cold moist one.

The great relative humidity of the air is a most important feature of the countries covered with snow in winter. It is as easy to account for it as for the humidity of an island in the middle of the ocean or of a place situated in an extensive swamp-tract. The wind may come from every side; it has always to pass over a large evaporating surface, and absorbs moisture if it was originally dry. In countries where cold strong winds predominate, as in the greater part of N. America and Eastern Asia, this will be less the case, as the winds, rapidly passing over the land, have not the time for absorbing much moisture, and the dryness of the air in the United States is felt by Europeans going there. But in countries situated like Europe and Western Asia, where the cold

inds are usually weak, and only the warm southerly winds rong, the air will be always nearly saturated, when the soil is a snow-covering, as the cold winds, in their slow progress, ive the time for absorbing moisture. This feature of climate is tremely important in the examination of storms. It was one of e chief merits of Espy to have pointed out the importance of por in the origin and progress of storms, and this is now genelly admitted. If a storm is signalized and the beginning of its path ated, it is important to know the quantity of vapor disseminated the countries where it is likely to pass, and the quantity which ay be expected to be condensed as rain and snow. Now, the wer the temperature falls, the more uncertain are observations the psychrometer, and I am of the opinion that it is not a sure ide below the freezing-point. This stated, it is very important to ve some general idea as to the quantity of vapor over the cold aces of the earth's surface. Now in countries situated like Europe, lative humidity will scarcely fall below 75–80° so long as the earth covered with snow, so that the quantity of vapor in the air of ese regions may be very nearly known if we know the temperare. In an examination of the barometric range in European issia and Siberia, some time ago, I have stated that not only the essure of the air rises in winter as we advance from the western ast of Europe into the interior of the continent, but the barotric minima rise even more, so that for example, in Nertschinsk, Eastern Siberia, the middle barometric minima of January, reced to the sea-level, are 30·23 in., and the lowest pressure happeng in 17 years in this month was equal to 29·93. If we consider that this place the temperature never rises above 14° F. in January, e effect of cold and small quantity of vapor in the air, in arrestg the progress of storms in winter will be clearly seen. In Euroan Russia the barometric minima are lower in winter than in e other seasons. This shows that the storms of the Atlantic ce their course over our country. Speaking generally, the path storms is from N.W. to S.E. in winter, because they cannot vance in an eastward direction as they began, being arrested the cold. The colder the temperature is, the sooner the storms ist turn to the southward, and this will be much more the case January than in November and March, when the storms of irope sometimes advance into the interior of Siberia.

Another feature of the snow is that of arresting the progress of nperature above the freezing-point so long as it lies. In rising ove, the heat is employed in melting the snow, or in the lanage of the mechanical theory of heat, it is transformed into work. e have some striking facts of this kind in Russia. For example, rnaul, in Western Siberia, has a winter temperature lower than Petersburg, by nearly 18° F. Yet the thermometer sometimes es as high as in this last place in winter, because Barnaul has Kirghi-steppes to the southwest. As they are seldom covered h snow, warm winds can pass across them and without losing

their heat, while before arriving at St. Petersburg, they must lose much of their heat in melting the snow over an extensive track. The result is, that seldom a winter month passes without temperatures above freezing-point, but in January and February the thermometer does not rise above 39°, while at Barnaul a temperature of 42° may occur at that time, (for example on the 4th, 5th and 6th of February, 1855).

I have mentioned already the effect of the snow in checking the rise of temperature, and employing more abundant heat in melting. This is most felt in spring, and lowers much the temperature of this time of the year, as for example, while in Central Europe, at some distance of the sea, April has nearly the same temperature as October, in the same latitude; in Russia the warmth of the sun's rays cannot raise the temperature of the air so much, and April is generally 4° F. colder than October, while May has the same temperature as September. As soon as the snow is melted our climate assumes its true continental character. In more northern parts of Russia it is May which stays behind September; as for example, at Archangel, Berezoe and even Yakutsk in one of the most continental climates of our planet in this last place May is more than 3° colder than September, while March is 13½° *warmer* than November.

I must now state a last point, the influence of forests in equalizing the layer of snow and giving to it all its beneficial effects. Without the forests a great mass of snow is often a check to all communication, as for example, at this moment in South Russia, where most of the railways are stopped. The untsually great mass of snow is blown in all directions by the wind, unimpeded by trees, as some of these places were always steppes, in others man was too short-sighted to let the trees stand. The effect of the melting of snow on the rising of rivers will be quite different in a wooded and a bare country. In the first the snow will lie sometimes a month longer than in the last, and accordingly the floods of the rivers will be longer continued but less high and devastating. Every one who has inhabited the country will be struck by this fact and its bearing on the climate and the well-being of the population all around. Generally speaking, as I have stated, the effects of a layer of snow are beneficent to man. The proportion of the crops is of enormous economical worth. The greater moisture of the air is also good, and even the cold of spring, caused by the melting of snow, has its good side. The too rapid advance of vegetation in early spring is checked by it, and protracted to a time when the vegetables have less to fear from night frosts. Northern Europe, for example, suffers much less from this curse than the south, where the returns of cold in spring cause great damage every year. Only two serious effects are sometimes felt, the interruption of communication in snow storms and the great floods of spring. But both of these drawbacks can be avoided by the foresight of man, as forests arrest the progress of winds and cause a slow melting in spring, so as to store a great quantity of water to supply our rivers.

St. Petersburg, 20th February, 1871.

2. *Scientific Expedition from Williams College.*—The scientific xpedition from Williams College, consisting of five members of 1e present senior class, under the charge of H. M. Myers, which ft the States last November for the purpose of making exploraions and collections in Central America, returned from that counry in March, having successfully accomplished the objects proosed. The party spent some time upon the elevated plain of 'omayagua, in Spanish Honduras, where they found the climate 1ost salubrious. One of the immediate results of the expedition s a fine addition to the cabinets of Williams College. The ornihological specimens secured, taken in connection with those added o the museums by the expedition to South America, in 1867, give he college a most valuable collection of tropical birds. Among he additions to the archæological department are two interesting tatues exhumed at Corosal, in British Honduras, ninety miles outh of Belize. The work upon these images, cut from limestone ock, is quite finely executed; and being still in a good state of reservation, they are valuable and interesting relics, marking the dvances in civilization made prior to the occupation of the country y the Spaniards. Although the table-lands and the Pacific coast f these Central American States have been frequently visited by ollectors, the low coast-lands of the northern slope have been alnost entirely passed by on account of their unhealthfulness. Colections from these comparatively new fields are especially valuale; moreover, the richness of the fauna and flora offer every nducement to the naturalist. It was upon these lowlands that he Williams College party made their largest collections.

3. *Description of a Tide-Gauge for cold climates;* by John M. Batchelder, of Cambridge, Mass.—This instrument is intended or registering the height of the tide at stations where the float nd box commonly used are liable to be obstructed by ice.

A strong iron tube, about four inches in diameter, is firmly boltd to a wharf or pile. It is open at the top, and has at the lower nd a nipple to which an India-rubber bag is fastened,—the length f the tube being sufficient to allow the elastic bag to be always ubmerged at the lowest stage of the tide.

The bag is supported by a suitable shelf, or cage, and is filled rith glycerine, which is poured in at the top of the tube. When n this condition the glycerine rises and falls within the iron tube n proportion to the varying height and pressure of the column of rater above the rubber bag, the difference in the height of the wo columns being in proportion to the difference of the specific gravity of the water and the glycerine. The parts above described nsure protection from floating ice, and prevent congelation within he iron tube.

A copper tube, about three inches in diameter, closed at the botom, and open at the top, is placed within the iron tube, and floats n the glycerine: if left free it would rise and fall with the changng level of this liquid. The length of the central tube is a little greater than the whole range of the tide.

Near the upper end of the outer tube, there are three spiral springs, fixed at the top and united at the bottom by a plate or disk, from which the central copper tube is suspended. From a stem fixed to the center tube or float, and moving with it, a string or chain leads over a single pulley, and gives horizontal motion to the pencil carriage of the recording apparatus.

The distance that the central tube is to move, vertically, is adjusted to agree with the required range of the pencil upon the record paper, by placing within it suitable weights.

As the glycerine falls or rises in the annular space between the iron tube and the central float, the spiral spring at the top is more or less extended, the extension being uniform on account of the cylindrical form of the float.

It is not necessary that the India-rubber bag be enclosed in a perforated box for the purpose of preventing oscillation: as it is always submerged, and the pressure upon it is equal to the weight of a column of water, having its base at the bag, and its summit at the mean level of the surface waves.

This instrument has been constructed by the United States Coast Survey, and is now in operation at the tidal station in the Boston Navy Yard.

4. *American Weather Notes;* by PLINY EARLE CHASE. (Read before the American Philosophical Society, March 3, 1871.—The signal service observations of our War Department have already shown the value both of Buys Ballot's law and of Capt. Toynbee's modification in predicting changes of wind, especially if due regard is paid to the barometric variations of the two previous days. They have also suggested the following general deductions, some of which may perhaps prove to be true only of the winter, while others seem to be explicable by natural circumstances of position and physical configuration, which must be operative at all seasons.

(1.) Winds varying like the land and sea breezes, are often traceable, especially in the lull which follows the passage of storms, to differences of temperature in the neighborhood of the great lakes, and of mountain peaks and ridges.

(2.) The wind, especially in the Southern States, often blows directly in the line of the greatest barometric gradient. But even in such cases, after a few hours continuance, it tends toward the azimuth indicated by Buys Ballot's law.

(3.) The isobaric lines are, therefore, often of less relative importance than the gradients in forming forecasts.

(4.) Long ridges of high barometer, as observed by Espy and others, with adjacent troughs of low barometer, often traverse the continent, sometimes with slight deflection, sometimes having a semi-circular, circular, or elliptical curvature, with a diameter of three thousand miles or more. Such ridges usually have a steeper declivity and stronger winds on their northerly and easterly than on their southerly and westerly sides.

(5.) Currents with an anti-cyclonic tendency, controlled by areas of high barometer, are notably common. Reversals of wind, as from N.E. to S.W., are, therefore, frequent after the passage of

ti-cyclonic ridge or center, as well as after the passage of a ne.

) Our recent storms have been anti-cyclonic, and there seems reason for supposing that anti-cyclones are the usual ther-breeders," even of such of our land storms as become or less cyclonic after they are fully developed.

) The precipitation of vapor of course gives rise to local cy-s, which, however, may be easily and speedily overborne by rand anti-cyclonic whirls of a half million miles or more in

) These and other peculiarities, point to a probable origin of is in the blending of polar and equatorial currents, near the des at which the general tendency of the winds changes its tion.

) Mr. Scott has observed that when polar (E.) currents are ing at the North, and equatorial (W.) currents at the South, ous barometrical disturbance, frequently resulting in a gale, ally soon follows; but when the polar current is at the and the Equatorial at the North there appears to be no law uence. The latter condition, with us, seems often indicative proaching fair weather, especially if northerly or easterly are ated from southerly or westerly winds by a ridge of high neter.

.) If the progress of a northerly or easterly current toward quator is impeded by an intervening southerly or westerly nt, the disturbance not only speedily follows, as indicated by cott, but it is also, commonly, like most showers, S.E. storms, ther marked cyclonic commotions, of briefer duration than which are primarily anti-cyclonic.

European and American Rain-falls; by PLINY EARLE E. (Read before the American Philosophical Society, March 71.)—There is still a lingering skepticism on the part of some rologists, regarding the moon's influence on the weather, a icism which is perhaps owing to the apparent want of agree-between observations at different places. There is, however, od reason for expecting such accurate correspondence as is imes deemed essential. Dr. Emerson (Proc. A. P. S., xi, has communicated to the Society his early observation upon eversal of the European Barometric prognostics on this side e Atlantic. Mr. Blodget (Climatology, pp. 221–237) has ed out various climatologic contrasts, and Mr. Scott, the Di-r of the British Meteorological Office, has noticed an opposi-etween the solar (or temperature) rain-falls in Western Europe Eastern America, analogous to that which I have indicated lunar rain-falls. The confirmation thus afforded to the re-of my previous investigations, strengthens the presumption in our Atlantic States, signs of fair weather may be most lently trusted during the ten days preceding, signs of rain g the eight days following, full moon.

order to make a comparison between stations of similar lati-I obtained from the "Observatorio do Infante D. Luiz," a

record of the quarterly rains at Lisbon for sixteen years, which I have embodied, together with the observations at Pennsylvania Hospital for the same period, in the following tables. The measurements are given in millimeters.

I.—*Quarterly Rain-fall at Lisbon.*

Years.	Winter.	Spring.	Summer.	Autumn.	Total
1855	280·3	272·7	15·4	362·5	930·9
1856	513·4	300·7	8·5	90·3	912·9
1857	267·8	152·2	67·9	324·4	812·3
1858	224·2	113·2	7·1	567·6	912·1
1859	128·0	201·8	71·6	306·9	708·3
1860	210·9	122·4	39·6	187·3	560·2
1861	501·5	154·3	14·6	311·4	981·8
1862	364·4	282·9	6·6	176·9	830·8
1863	181·8	196·6	64·8	101·6	544·7
1864	155·3	282·2	33·9	363·5	834·9
1865	371·6	159·2	24·4	487·2	1042·4
1866	214·7	365·3	14·6	82·3	676·9
1867	197·2	216·2	13·6	172·1	599·1
1868	162·9	76·9	38·0	279·4	557·2
1869	323·2	158·5	3·1	66·0	550·9
1870	305·7	111·6	21·9	160·3	599·5
Mean	275·2	197·9	27·9	252·5	753·4

II.—*Quarterly Rain-fall at Philadelphia.*

Years.	Winter.	Spring.	Summer.	Autumn.	Total.
1855	193·0	169·9	435·4	257·8	1056·1
1856	284·5	211·8	241·3	187·5	925·1
1857	184·4	359·9	482·6	133 4	1160·3
1858	264·9	272·8	274·1	227·1	1038·9
1859	376·7	376 9	376·4	371·6	1501·6
1860	240·3	229·6	311·7	342·9	1124·5
1861	269 8	362·5	243·3	332·0	1207·6
1862	292·6	254·5	263·1	343·9	1154·1
1863	280·7	442·0	297·4	153·4	1173·5
1864	174·8	448·3	204·2	327·9	1155·3
1865	370·1	374·7	291·9	380·3	1416·9
1866	390·4	247·9	194·6	370·9	1203·8
1867	230·1	370·6	742·5	228·1	1571·3
1868	225·3	401·3	268·0	404·6	1299·2
1869	318·5	296·2	247·7	337·8	1200·2
1870	297·7	404 9	303·8	195·8	1202·2
Mean	274·6	326·5	323·6	287·2	1211·9

It appears, therefore, that the heaviest rain-falls at Lisbon and the lightest at Philadelphia, are usually in the Autumn and Winter semester; the heaviest at Philadelphia and the lightest at Lisbon, in the Spring and Summer. In ten years out of the sixteen, when the rain-fall of the entire year was above the average at one station, it was below the average at the other.

6. *Discovery of the Animal of the Spongiadæ confirmed;* By H. J. Carter, F.R.S. &c. (Ann. Mag. N. H. IV, vii, 445). Just a line to tell you what you will be glad to learn, viz. that I have confirmed all that Prof. James-Clark, of Boston, has stated about the sponge-cell, and much more too.

It is, after all, only what was published and illustrated in the 'Annals' in 1857. Indeed I am astonished now at the accuracy and detail of that paper ("Ultimate Structure of Spongilla," &c.), now *all* confirmed by an examination of a *marine* calcareous sponge.

I have not only fed the sponge with indigo, and examined all at the moment, but the sponge so fed was put into spirit directly afterward, and *now* shows all the cells (monociliated) with the *cilium attached and the indigo still in the cells.*

This, I think, will break down Häckel's hypothesis, which is as imaginative and incorrect as it is beautiful.

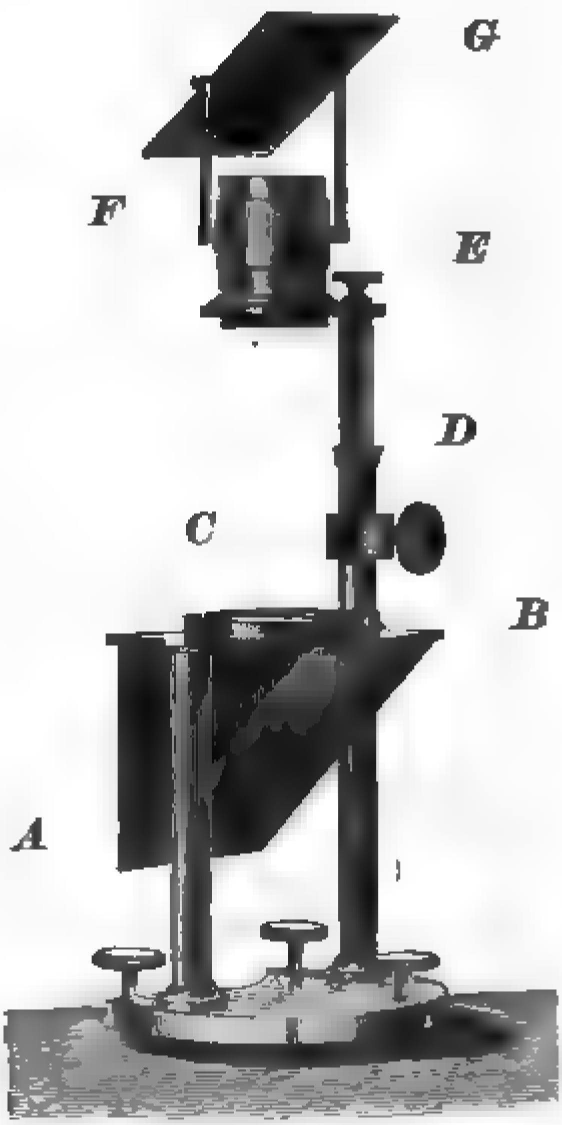
His "Magosphæra," too, is figured in the 'Annals' (1856), and described *in extenso* as the amœboid cell which inhabits the mucus of the cells or internodes of the Bombay great *Nitella.*

But there are no people in England, if on the Continent, who seem to be able to show this, if even they be cognizant of it.

Ex oriente lux used to be the old phrase: the light is now being *reflected* back from America. It is from there that we must expect novelties now.

"The Cottage," Budleigh-Salterton, May 22, 1871.

w attachment for the Lantern.—It is often desirable to on a screen the images of objects which must be preserved ontal position; such for example as liquids, or solids im- liquids. Various devices have been tried for securing all of them more or less imperfect. Recently, however, Morton, of the Stevens Technological Institute at Hobo- devised a form of apparatus for this purpose which is ple and ingenious, and which answers its purpose ad- This "vertical lantern" as he calls it, is shown in the ac- ng figure. It is to be placed in front of the ordinary ›x, the condenser being composed of three lenses; the of these being of such a curve as to give, with the light › inches from the nearer one, a practically parallel beam. 1 enters the apparatus at eived upon a mirror in- ', which reflects it verti- ugh the third lens placed lly at C. This lens con- the beam upon the object :, after passing which, it d upon the screen by the nirror FG. Though the all of them uncorrected, mirrors silvered on the e ordinary way with pure there is no want of defi- he images produced, and is too slight to be appre- an audience. We wit- e performance of the in- a short time ago with sfaction. A glass plate, overed with iron-filings, ced above the lens C, a gnet was laid beneath it, plate gently tapped with The filings gradually themselves in the well- urves, producing finally tic spectrum of great A shallow tank of water n placed in the same



the images of waves, ingeniously produced by puffs of thrown upon the screen, and the various phenomena of ce and reflexion beautifully illustrated. Tomlinson's figures, produced by allowing drops of various essential upon water, were also superbly demonstrated. By using plates covered with sand, Chladni's sound figures may y be developed upon the screen in a striking manner. paratus was manufactured by Messrs. Hawkins & Wale en. It is exceedingly creditable to them in the excel- ts construction and finish. G. F. B.

8. *Report on Barracks and Hospitals, with descriptions of Military Posts.* 4to, pp. 494.—Under the modest heading of "Circular No. 4," the Surgeon General's office of the U. S. War Department at Washington has issued a valuable document with the above title, containing a great amount of valuable information respecting distant outposts but little known, geographical, topographical, meteorological, sanitary, &c.

In an appendix are "Reports on Examination of Air in Barrack rooms," giving the results of chemical analysis of the air at night

Tabular Statement of four Analyses of Air in Military Barracks, made by Capt. Lorenzo Louvain, assisted by Lieut. John Pitman, and reported by Surgeon V. B. Hubbard.

Experiment.	Time of observation.	Tempt. Fh.	Apartment.	Contents.		Estimation of carbonic acid.		Estimation organic matter.		Superficial area of doors & windo's open at the time in feet.
				Men.	Cubic feet of air.	Volume of air examined in c. c.	Volumes of CO_2 found in 10,000 vols.	Vol. of air examined in c. c.	Organic in 1000 c. c. of air.	
1	1.30 A. M., July 22, '70.	81°	Artillery barrack.	19	13,016·25	3700	9·58	34·091	·00440	131·75
2	3 A. M., July 22, '70.	78°	Cavalry barrack.	16	16,803·36	4340	9·30	34·092	·00292	111
3	2 A. M., July 26, '70.	85°	Engineer barrack.	9	6,296	....	9·37	....	·00343	63
4	2 A. M., July 28, '70.	77°	Cadet hospital.	4	4,480	...	5·68 5·52	....	·00187	73·35

in barracks occupied by sleeping soldiers. Assistant Surgeon V. B. HUBBARD reports four analyses of air from the apartments of the U. S. Military Academy at West Point, N. Y., made by the Captain and his assistant, which we have arranged in a tabular form for convenience of comparison. R. S.

9. *Captain Hall's Arctic Expedition.*—The Polaris, the vessel for the Arctic Expedition under Captain Hall, is now in New York (June 15), at the Navy Yard in Brooklyn, where she will remain ten days, or until ready to start northward. She will take in supplies to last to Disco in Greenland, where she will await the arrival of the storeship Supply, with additional provisions. Captain Hall contemplates an absence of two years and a half, and if results warrant, the voyage may be still farther prolonged. From Disco the expedition will proceed to Uppernavik or Tissonack, the most northern settlement of Greenland, where gangs of dogs will be obtained. The Polaris may have to winter in Jones' Sound, the latitude 76°N., but if possible will be pushed on to 80°N. Early in April, 1872, the journey over the ice toward the Pole will be begun. Hall asserts that if Ellesmere Land, which reaches from Jones' Sound northward, extends upward to the Pole, he is confident of reaching the great object of his destination in at least 100 days from the time he leaves the ship with his boats and sledding party. Should the land and ice terminate in an open Polar sea, his boats will be used on that as yet mythical sheet of water to complete his discoveries, precisely in the same manner as they will be employed in transporting the party from

ıe flōe to the other whilst among the field ice. The chief of the ientific corps attached to the expedition is Dr. Emil Bissels, who as a member of the recent Prussian expedition to the North ole. He is a young man with a high reputation as a scientific udent, and is a graduate of the famous University of Heidel- erg.

Besides Capt. Hall and Dr. Bissels, quite prominent characters e the sailing-master, Capt. O. S. Buddington, who has had thirty- ro years' experience as an Arctic navigator, Mr. Hubbard C. hester, of Noank, Conn., the first officer, and Mr. William Mor- n, who is said to have discovered the open Polar Sea while on e first Grinnell Expedition, who goes out as the second officer. ergt. Meyer, of the United States Signal Corps, has charge of the eteorological department. R. W. D. Bryan is astronomer.

Two of the most interesting individuals who accompany the :pedition, are the Esquimaux man and woman, who have been ith Capt. Hall since his first essay in Arctic explorations.—*New 'ork Times*, June 15.

10. *The so-called* "*Cardiff Giant.*"—It will be remembered that, ro or three years since, a considerable excitement was created by e alleged accidental discovery upon the farm of a Mr. Newell, ar the city of Syracuse in the State of New York, of a human gure of gigantic proportions, which was exposed during an excava- on undertaken by the owner with the avowed purpose of digging well for the supply of water to his cattle. The obvious folly of :cavating for a well in the bed of a stream of water was commented ı at the time and was not easily explained away. The popular petite for marvels was, however, adroitly quickened by the story st of a "fossil man," of pre-historic age; for who did not believe at "there were giants in those times?" The absurdity of such a eory soon compelled the milder statement that while the recum- nt giant was of acknowledged human origin, it was unquestion- ly of an unknown but very high antiquity, and hence must pos- ss great archæological interest. With this hypothesis the so- lled "Cardiff Giant" commenced his tour of exhibition, after ousands of curious spectators had visited him in his resting place he lay exposed in the excavation upon the Newell farm: and for time multitudes thronged the places in various cities where this pposed relic of an earlier age was to be seen. We have lately d the matter brought home to our own doors through a visit of is venerable personage to New Haven, and although we had sup- ›sed the fraud had long since ceased to be capable of exciting ore than a feeling of contempt, mingled with curiosity to see by hat means the delusion was produced, we have been surprised at e facility with which people, otherwise sensible, give credit to the eatest absurdities, even after the "humbug" had been fully ex- ›sed. We think therefore it is worth while to record very briefly e real history of this sham, that it may find its place in the ready large catalogue of popular delusions. We suppress names, ıt give the main facts as we have ascertained them from an in-

telligent witness who was cognizant of the origin and progress of the statue.

The block of gypsum, from which the Cardiff Giant was carved, was quarried near Fort Dodge, in Iowa, where there is an inexhaustible supply of massive gypsum of Mesozoic age.* It was transported to Chicago, in Illinois, where it was placed in the workshop of Mr. Burckhardt, a well-known marble-worker of that city, who contracted with the originators of the scheme for a not very considerable sum of money, to produce a gigantic recumbent figure of a man. His position, resting with the left arm under the body, the right arm thrown across the body over the pelvis, and with the legs slightly flexed at the knees, was measurably a necessity of the form of the block of stone at the artist's command. This figure was first modeled in clay by or under the direction of Mr. Burckhardt, and was then transferred to the stone. Our informant states that he saw the figure more than once during its preparation. The appearance of age was given partly by treating the surface with acids to remove the tool marks and the raw look of a recently tooled surface, and this effect was subsequently heightened by the grime and soil of a seven months' interment. Thus prepared, the newly-made antique was transported by rail to a point near the Newell farm, and thence by teams to the farm itself, where, by the aid of a body of work people, brought from a distance, it was placed in its resting place, near the bed of a small stream. Those engaged in the work of removal and interment were taken away furtively, and thus no one at or near Syracuse but those engaged in the speculation knew of its existence. By a singular accident, an eye-witness to its making in the Chicago work-shop happened to be in Syracuse at the time its discovery was announced, and, visiting the Newell farm with the crowd of curious spectators, was surprised to see there his old acquaintance half buried in the earth. We have taken pains to verify this statement, and are promised at an early day a detailed statement from the work shop of Mr. Burckhardt of its entire history, which we may take another occasion to publish. B. S.

11. *Party of Exploration under Dr. Hayden.*—Dr. Hayden and party (as a letter from him informs us) were at Ogden, Utah, on June 8th. The party comprises thirty-two men (including an astronomer, topographical engineer, etc.), five wagons, two ambulances, forty-eight mules and horses. He proposes to connect with the belt under exploration by Clarence King, and then spend the remainder of the season about the sources of the Yellow Stone and Missouri rivers. He has a boat and sounding apparatus for making a complete survey of the Yellow Stone, etc. A company of cavalry is ordered as an escort from Fort Ellis. He expects to return to Washington about the 1st of November. Congress made an appropriation of $40,000 for the explorations of the season.

* See Dr. White's report on the Geology of Iowa, vol. ii, p. 299.

2. *Survey of the Great Lakes.*—We take the following notes this survey from Harper's Weekly of June 10th, a periodical ich has in each number one or two columns of recent scientific elligence furnished by a correspondent who is a man of thorough ence, and in the way of knowing what is doing in science.

Among the United States government explorations to be prose- ed during the present year, we should not omit to mention that he Lake Survey under the Engineer Bureau. This work has n in progress for a number of years, and in the reliability of the ervation and the beauty of the maps published occupies the y first rank. The work is at present under the charge of General B. Comstock, and will be carried on in several localities simul- eously. The survey of Lake St. Clair, which was nearly finished year, will be completed the present season; and the party, on shing it, will then proceed to the St. Lawrence River, in the ghborhood of Ogdensburg, and there carry on their labors. Both res of Lake Michigan will be surveyed during the season, com- ncing at Sheboygan on the eastern shore, and at a point north Grand Haven on the western. It is expected that the whole will completed as far south as Kenosha before operations are inter- ted for the winter. Triangulations will be conducted along ce Michigan between Green Bay and Milwaukee. In addition the hydrographical and surveying work prosecuted by these ties, great attention is paid to securing reliable data in regard he meteorology of the country, with the special view of deter- ning the average conditions of rain-fall and other phenomena.

The data already collected have been of great value, and have le much toward supplying accurate information."

3. *Geological Survey of Canada:* Alfred R. C. Selwyn, *rector.*—Report of Progress from 1866 to 1869. 476 pages 8vo. companied by Geological and Topographical Maps. (Dawson s., Montreal; B. Westermann & Co., N. York).—This volume tains a report of Sir Wm. E. Logan on a part of the Pictou l-field, 50 pages; of E. Hartley on a part of the same coal-field, pp.; of R. Bell, on the Manitoulin Islands, 9 pp.; of J. Richard- , on the South Shore below Quebec, 23 pp.; of H. G. Vennor, Hastings Co., 28 pp.; of C. Robb, on a part of N. Brunswick, pp.; of T. Sterry Hunt, on the Goderich Salt Region and Notes Iron and Iron Ores, 94 pp.; of J. Richardson for 1869, 6 pp.; R. Bell, on Lakes Superior and Nipigon, 52 pp.; of E. Hartley, Pictou coals and Iron ores, and on Springhill Coal, 82 pp.; h an appendix containing a list of plants collected in the nitoulin Islands, by Dr. John Bell. The excellent maps add ch to the value of this interesting volume.

4. *North Carolina Tertiary.*—Mr. Conrad states in a recent ter to one of the editors, that the fossil horse of the marl near eenville, N. C., mentioned in this Journal, last volume, on page), is, according to Dr. Leidy, the *E. complicatus*, a Miocene cies that lived with the *E. fraternus.* The Mastodon from leigh (p. 469) is the *M. Americanus*, and was from Quaternary vel overlying the Miocene marl.

15. *Volcano of Kilauea, Hawaian Islands.*—A recent letter from Rev. T. Coan states that the crater is at present in an unusually quiet state. Even the region of the great South lake, sometimes boiling with lavas over an area half a mile broad, is wholly inactive excepting the escape of vapors from fissures. At a depth of one hundred and fifty feet in some of these fissures a red heat may be seen, but no liquid rock.

VI. Miscellaneous Bibliography.

1. *Smithsonian Contributions to Knowledge.* Vol. xvii. 4to, pp. 590, with 14 plates.—This volume is devoted to an elaborate memoir entitled, "*System of Consanguinity and Affinity of the Human Family;* by Lewis H. Morgan."—This memoir was referred to a commission consisting of Prof. J. H. McIlvaine and Prof. William H. Green of Princeton, and after certain modifications suggested by them had been made, in the method of presenting the subject, it was submitted to a special committee of the American Oriental Society, consisting of Messrs. Hadley, Trumbull and Whitney, who, after a critical examination, reported that the memoir contained a series of highly interesting facts which they believed the students of philology and ethnology, though they might not accept all the conclusions of the author, would welcome as valuable contributions to science.

2. *Manual of Geometrical and Infinitesimal Analysis;* by Prof. B. Sestini. (Murphy & Co., Baltimore.)—In the brief space of 131 pages, the author gives a *manual* of the processes and results of Analytical Geometry and Calculus. While he does not claim to give a treatise, he briefly and lucidly develops all the important formulas of both branches of Analysis, especially the formulas reached in the study of Physical science.

A Dissertation on the Principles and Science of Geometry. By Lawrence S. Benson. New York: C. H. Phelps, publisher. 8vo.

Recherches sur la Polarization Rotatoire Magnétique des liquides, par M. le Professeur A. De La Rive. 8vo, pp. 46.

The Mineral and other Resources of the Argentine Republic. Published by special authority of the National Government, by Major J. Rickard, F.G.S. 1870. London: (Longmans & Co.)

Studien über das central Nerven-System der Wirbelthiere, by Dr. L. Stieder, of Dorpat.

Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., vol. ii, No. 3. On the Mammals and Winter Birds of East Florida, with an examination of certain assumed specific characters in birds, and a sketch of the bird Faunæ of Eastern North America, by J. A. Allen. 450 pp. 8vo, with 5 plates.

American Journal of Microscopy, devoted to elucidation of scientific and popular Microscopy; E. M. Hale, M.D., Editor, Chicago. No. 1 of this monthly on Microscopy containing 32 pages, appeared in April last. It aims to distribute in a popular way interesting information on Microscopic objects throughout the country. Subscription price $2.00 per year, or 25 cents per number.

Introductory Text-book of Meteorology, by Alexander Buchan, M.A., F.R.S.E., Sec. of the Scottish Meteorolog. Soc. 218 pp. 12mo, with several maps. Edinburgh and London, (Wm. Blackwood & Sons). A good work.

APPENDIX.

Letter to the Editors from Dr. B. A. Gould, *Director of the Cordoba Observatory, dated Cordoba, April* 26, 1871.

When I wrote you, at the beginning of November, I felt small doubt that our Observatory would be in working order so far as mason work and carpentry were concerned, before the commencement of the New Year. The brickwork was completed at the close of November as I had anticipated; but even now as I write, the portion of the building which was first provided is not finished, although a very few days will enable me in all probability to begin the mounting of the instruments. So far as delays and interruptions of every sort are concerned, the enterprise has met with a very exceptional amount of obstacles, and only three days ago my instruments arrived from Germany after ten months of delay from war, ice, storms and quarantine.

The meridian circle and photometer are now securely housed, and, so far as I can yet judge, have suffered no essential injury. Our little library too has arrived, and I need not say with what earnestness we are looking forward to a sight of the catalogues and books of reference, now hidden within the iron-bound boxes. Should no unexpected obstacles arise, we shall be able to put up some bookcases, and unpack the boxes within the coming week.

It is now seven months since our astronomical party arrived in Cordoba, and during this long period we have been without instruments, and nearly destitute of books, notwithstanding the many precautions taken to avoid such a contingency. Fortunately I had brought with my personal effects the catalogues of Lacaille, Brisbane, Taylor and Ellery; and the catalogues published by the British Association were sent me from England. Thanks to these, I am indulging the hope that these seven months will not prove to have been spent in vain.

As intimated in my former letter, I resolved, as soon as the delays became manifest, to turn our attention to the formation of a Uranometry of the Southern sky:—in other words, to the preparation of a catalogue of all stars between the South Pole, and 10° of N. Declination, which are here visible to the naked eye, assigning to each star its estimated magnitude. This work has been now actively going on for six months, and with a degree of success which I had scarcely ventured to anticipate. The sky of Cordoba, although very far indeed from rejoicing in that eternal spring and unclouded blue which I had been led to expect, possesses when clear a wonderful transparency, and exhibits to the sharp eyes of my assistants an almost incredible number of faint stars, probably at least twice as many as can be seen in the most favorable nights at home. The lowest limit of visibility to the unaided eye, I have not yet undertaken to determine; but we see fully one-third of all the stars recorded by Lacaille as of the 7th magnitude, and we have a dozen or more of cases where Lalande has noted the star as 8th.

Our scale of magnitudes is based upon that of Argelander in his *Uranometria Nova*, and to secure as complete an accordance as possible our comparisons are made with stars observed by him within the zone comprised between 5° and 15° of N. Declination, since this zone has the same meridian altitude at Cordoba and at Bonn, and the light of the included stars is thus similarly affected by atmospheric absorption.

The establishment of standards of magnitude within this belt has been by no means the least laborious and troublesome portion of the undertaking; since no star is accepted as a standard to which the same magnitude has not been assigned by the independent estimates of four observers. The large number of stars within this type-belt, which could not be seen by Argelander in Bonn, affords an excellent measure of the transparency of the sky of Cordoba.

For constellations farther South the comparison is of course not so fair, on account of their superior altitude here, still you may form some idea of the work in hand when I tell you that in *Orion* we have twice the number of stars given by Argelander, and that in *Canis Major*, the whole of which is visible at Bonn, though to be sure its Southern boundary has only an altitude of a little more than 6¼°, we have 200 stars, while Argelander saw but 39.

A good deal more than half the work is now done; perhaps two-thirds of the hemisphere have been pretty well scrutinized, and the work of reducing the stars places to the mean equinox adopted is very well advanced. The total number of stars recorded thus far is about 4100, exclusive of those observed in the type-belt.

The delays of our instruments and of the Observatory building, though in themselves vexatious, have thus been compensated by the opportunity of preparing the Uranometry which ought to be essentially completed by the first of October, unless this should in its turn be too much delayed by the new work soon to be undertaken, in conformity with my original plan. An essential feature of my present scheme for the Uranometry consists in careful measurements of the magnitudes of stars above the 4th magnitude, and for these, of course, the greater part of a year must elapse after the photometer shall have been put in order by repairing the small damages which it has suffered on the voyage.

Our observations have greatly impressed me with the thoroughness and excellence with which Lacaille accomplished his work at the Cape of Good Hope with the poor means at his disposal nearly a century and a quarter ago. This devoted astronomer, having only a telescope half an inch in aperture and magnifying 8 times, observed, within a period of 11 months from the commencement of the series, something more than 100 zones, covering the region South of the Tropic of Capricorn. Like those of sundry other astronomers, most of his observations remained unreduced for the greater part of a century; but the catalogue computed from these observations at the expense of the British Association for the advancement of Science, and published by that body in 1847, contains the places of nearly 10,000 stars, which experience shows to have been determined with a degree of precision decidedly greater than he himself had supposed. And although his zones overlapped but little at their margins, so that only a small proportion of the sky was observed more than once, the scrutiny must have been extremely thorough for such stars as his little telescope would make manifest. The number of stars south of the Tropic, which we have detected, and which are not in his catalogue, is relatively quite insignificant, so that the task of identification has been by far less difficult than I was prepared to expect.

The recent publication, by Admiral Sands of the Washington Observatory, of Gilliss's Southern Catalogue of about 2000 stars affords a valuable supplement to Lacaille, since it gives observations of many stars for which there seemed reason to suspect errors in Lacaille's determination. And if, as recent letters from home give reason to hope, this is to be followed by Gilliss's splendid series of zone observations, comprising some 23,000 stars within 24° of the South Pole, observed in Chile twenty years ago, the Southern observer will receive a truly effective assistance in his labors. Indeed, after so long a period of apparent inaction, a new day seems dawning for stellar astronomy in the Southern Hemisphere. The careful and abundant observations of Maclear at the Cape of Good Hope, which have been accumulating for a quarter-century are now to be reduced and catalogued by his energetic successor Mr. Stone; and from the shores of Australia we are already receiving, thanks to the industry and ability of Mr. Ellery, an annual instalment of meridian observations, which may fairly challenge comparison with the most exact which are furnished by the first observatories of the Northern Hemisphere.

The difficult question of the Southern Constellations is of course now forcing itself in an especial manner upon my attention, in connection with the Uranometry. What constellations to retain, and what to disregard among the various suggestions of various astronomers, has been a less difficult question than the assignment of boundaries or the adoption of a definite and consistent notation from out the chaos which rules in sundry portions of the Southern sky. These matters, comparatively insignificant in many relations, acquire a supreme importance when questions of nomenclature become prominent, as in the work now in hand. Bayer, whose authority is accepted as law for the notation of Northern stars, named many of the Southern stars simply from descriptions given him by Southern navigators. Lacaille was either unaware of Bayer's notation or gave no heed to it, and later astronomers have increased rather than diminished the confusion. The difficulties were ably pointed out by the younger Herschel, but such few remedies as he suggested have tended rather to aggravate the evil, as for instance, in the case of *Argo Navis*, where the practical and effective suggestion, adopted by Baily, in the three catalogues of the British Association, of dividing this huge and unwieldy constellation into four smaller ones corresponding to the parts of the Ship, as indicated by Lacaille, is more than counterbalanced by the other recommendation, likewise adopted by Baily, that so far as the Greek alphabet is used, the original constellation be retained, while each of the four sub-constellations has its own special nomenclature in the two series of letters of the Latin alphabet. Nor are the three catalogues edited by Baily for the British Association altogether accordant as regards either the constellation-boundaries, or the notation of the stars, notwithstanding his efforts to furnish some relief for the existing confusion. The same Greek letter occurs twice in the same constellation in more than one instance in these catalogues, while other letters are entirely wanting.

Let me give you an illustration of the confusion encountered in a study of prominent Southern stars. Take the constellation *Telescopium*, one which has every reasonable claim to be accepted and retained. Here B is in fact η *Sagittarii*, γ, η, and o are in *Scorpius*, and σ is in *Corona Australis*. Or take *Piscis Austrinus* and follow the catalogues. Here Brisbane's ϵ is Baily's γ; Brisbane's η is Taylor's o and Baily's δ; Brisbane's γ is Baily's ϵ, while Taylor gives it no letter. Brisbane has two κs, one being Bayer's η, while Baily assigns no letter to the other; but Bayer's κ is γ *Gruis* of Lacaille (and Baily). Brisbane's ι is Baily's (and Bayer's) μ; of Brisbane's two δs one is Baily's τ, and the other has no letter in his catalogues; Brisbane's ν is Taylor's ω, while Baily gives no letter to it; Taylor's γ, ϕ and ψ have no letters given to them by either Brisbane or Baily. Indeed Baily puts ϕ in Aquarius.

Now the application of any general rule seems out of the question. For such stars as are visible in Central Europe, Bayer's notation should assuredly be retained, yet for many stars farther South, the star actually cannot be identified with certainty to which his letters were intended to apply. Where Bayer's notation fails, Lacaille's has the next claim; yet in many instances he has employed a letter already assigned by Bayer in a more Northern portion of the same constellation. Not unfrequently too Baily has attempted to improve upon both Bayer and Lacaille, and not with the best success; yet inasmuch as every existing Southern Observatory, so far as I am aware, has been organized by some astronomer whose native tongue was English, and who has therefore depended to a greater or less extent upon the three catalogues of the British Association, this "improved" notation, like the "improved" notation of Bessel's star-constants, a, b, c, d, has found a wide adoption.

Add to this that, so far as I am aware, no attempt has been made to give precise boundaries to the several constellations, and you will see that the task of arrangement is no slight matter, when every visible star is to be assigned to some definite constellation. This implies the establishment of boundaries,

and one needs but to glance at any celestial globe or atlas to convince himself that this is a process more easily spoken of than accomplished. If performed in a manner acceptable to astronomers it will find prompt adoption, and evoke order from confusion; if, however, it should fail of approval, it will but add one more chaotic influence. Any attempt at such a revision and establishment of boundaries should be restricted by certain fixed regulations, prescribed in advance, and not to be transgressed upon any pretext; if such can be judiciously laid down, and yet found upon trial not to be incompatible with an arrangement of boundaries easy of recognition and of description, I see no reason to doubt their glad reception by astronomers, as a simple means for substituting for the existing confusion a well ordered and unmistakeable system.

Notwithstanding some misgivings, I am at present occupied in the attempt to arrange the Southern constellations in such a way that the changes may be regarded by astronomers as only for the better.

During the last week we have unpacked the equatorial, and have mounted its bed-plate upon a pier of white marble, from the Sierra four leagues away. The instruments appear to have arrived in perfect condition, and as soon as the dome is made rain-tight, and the interior of the building plastered, I shall proceed to the mounting of the telescope, for which all needful preparations are already made. That the shutters should be rain-tight, is a much more essential condition than I had been led to suppose, for the summer rains here are sudden and vehement. The theory of an eternal summer is thoroughly disposed of; for during the last three months we have not had a dozen perfectly clear nights, the sky being overclouded with almost perpetual nimbus, although very little rain has fallen This, I am informed, is the ordinary character of the weather during a considerable part of March and April, the autumn being ushered by a long cloudy season. I wrote you before that I had known no rain here without abundant thunder and lightning. During this long cloudy season a light misty rain has several times occurred without electrical manifestations, although as regards regular showers or copious rains. I have seen no reason to change my earlier impression. The rainless season is now said to be close at hand. It will assuredly find with us a cordial welcome.

It is to be expected that in the course of our work we may encounter a number of variable stars sufficient to make the number in the Southern Hemisphere approximately equal to that of those already known north of the Equator. As yet however we have not followed through any very decided changes, although there is a considerable number of stars whose magnitudes, as observed by us, differ widely from those recorded by other astronomers, and which also appear to have varied during the period of our observation.

The star η *Argus*, has naturally attracted a good deal of my attention. It is at present not far from the 6¼ magnitude and recognizable with great difficulty by the naked eye. In the field of my small Tolles telescope of 5 in. aperture, and 35 in. focal length, it is a conspicuous object, and prominent by its ruddy color among the cluster of which it forms a part, against the bright nebula as a background. With this telescope, the same one which I employed for observing the total eclipse of 1860, I have been examining the whole group: and have found to my astonishment that it exhibits with distinctness a considerable number of stars, which are recorded in Sir J. Herschel's catalogue of this cluster, as being of the 14th magnitude.—(*To be continued.*)

Party of Geological Exploration under Prof. O. C. MARSH.—Prof. Marsh, with a party of twelve, is about leaving for the Rocky Mountain region and the Pacific coast, to continue his investigations with reference to the Cretaceous and Tertiary vertebrates of the region. He will be absent about six months.

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[THIRD SERIES.]

ART. XI.—*Historical Notes on the Systems of Weather Telegraphy, and especially their Development in the United States;* by CLEVELAND ABBE, A.M.

THE recent establishment in our own country of a national System of Weather Reports and the general interest in this enterprise, has induced me to accede to the request of the Editor of this Journal, and to offer the following notes relating to the development of the idea of storm warnings.

It was evidently possible to study with advantage, the progress of atmospheric changes only when the telegraph lines had become widely extended over the earth's surface. It was through the public press—the daily newspaper—that it first became possible to watch the hourly progress of storms, under one's own eye, and to confirm the general laws independently deduced from the closet studies of the professional meteorologist. The first mention that I find of the systematic daily use of these daily press reports, is given by Kämtz, in his "Repertorium," wherein it appears that already in 1835, he began to collate the weather reports published in the Vossische Zeitung of Berlin. In the subsequent history of Weather Telegraphy in Europe, I first find a suggestion by John Bell, made in 1848, at the Swansea meeting of the British Association for the Advancement of Science, that in London it was already possible to receive weather reports with only a few hours' delay, from most parts of Great Britain and Europe, and that this information ought to be utilized for the study and prediction of storms. The general press reports seem to have continued to be in

Europe the only source of information regarding the impending weather, until Le Verrier first began to publish the Bulletin International. Already in 1854 he had urged the importance of systematic telegraphic weather reports, and in 1855 the Emperor Napoleon sanctioned the beginning of the undertaking: the stations from which reports were received during the first two years were confined mainly to France, but the network of stations was extended to foreign countries in 1857. In 1858 all the important cities of Europe were included, and on the 1st of January of this year began the publication of the "Bulletin International,"—previous to this the telegraphic reports had been distributed gratuitously, but only to the observers and others immediately engaged in the work. With September, 1863, began the publication in the Bulletin of the chart and the isobaric curves for Europe. During the previous six years LeVerrier had met with insurmountable obstacles to the systematic utilization of the weather reports, by disseminating predictions of storms, &c.,—but occasional warnings had been issued, and the practicability and importance of the matter had been faithfully urged by him. In this year (1863) stimulated probably by the success of Fitzroy in England, the obstacles were partly removed, and the French system of daily probabilities of weather was inaugurated. In 1865 the coöperation of the French marine was obtained, and with this year begins the series of quarterly volumes of the "Atlas Généraux des Mouvemens de l'Atmosphère." To the preface of this vol ume we must refer for the fullest detail of LeVerrier's undertakings.

The storm warnings issued since 1860 by Buys Ballot in the Netherlands, and those of Fitzroy (died, May, 1865), and Babington in England (Feb., 1861, to Dec., 1865), followed upon the growing success of the French system; and the recent extension of these to India and Russia, as well as the system now being organized in Australia, need but to be mentioned. The present English system in charge of the "Meteorological Committee," is in some respects very different from that established by Fitzroy: it began its publication of weather intelligence in December, 1867.

While thus practical meteorology has made brilliant progress in Europe, we cannot forget that the original impulse to this success was given by the labors of our own countrymen. Franklin* is said to have been the first who strictly defined and published the general law that the storms of our Southern States move off to the northeastward over the Middle and

* Earlier than Franklin must have been Lewis Evans, who, according to Hon. T. Pownal, M. P., published in 1749 at Philadelphia, the brief statement of this general law. (See Blodget's Climatology, p. 379).

Eastern States, preceded by northeastern wind and rain, and these latter followed necessarily by low barometer and westerly winds, with clearing up weather. In this we recognize the original of the generalizations of President Jefferson and Dr. Mitchell, as published in their writings, and something a step in advance of the propositions of Lavoisier, for the study and prediction of storms. (See Atlas Généraux, 1865, p. 13).

To Sir Wm. Reid and W. C. Redfield, (this Journal, 1831) is due a clear analysis of the elements of storms and the deduction of the more general laws followed by them. To the generalizations of these authors relative to the ocean storms of the Western Atlantic, Espy (Philosophy of Storms, 1841, and Reports, 1854), and Loomis (on the Storms of 1836, 1842, &c.) added others referring to the storms of our interior, and to the origin of atmospheric disturbances. To Ferrel (the Motions of Fluids and Solids, 1856 and 1860) we owe the most complete mathematical investigations into the general and the special movements of the atmosphere.*

However frequently the idea may have been suggested of utilizing our knowledge by the employment of the electric telegraph, it is to Professor Henry and his assistants in the Smithsonian Institution that the credit is due of having first actually realized this suggestion.†

The practical utilization of the results of scientific study is well known to have been in general greatly furthered by the labors of this noble Institution, and from the very beginning Professor Henry has successfully advocated the feasibility of telegraphic storm warnings. The agitation of this subject in the United States during the years 1830–1855, may be safely presumed to have stimulated the subsequent action of the European meteorologists. It will be interesting to trace the gradual realization of the earlier suggestions of Redfield and Loomis, in the following extracts from the annual Smithsonian Reports of the respective years.

* Meteorological studies were actively carried on by the Joint Committee of the American Phil. Soc. and of the Franklin Institute, from 1834 to 1838, Professor Espy being chairman, and were furthered by the Franklin Kite Club in the latter year.

† See Vienna Acad. Sitzungsberichte.

The first published suggestion that I have found is by the lamented Redfield; this Journal, Sept. 1846.

"In the Atlantic ports, the approach of a gale may be made known by means of the electric telegraph, which probably will soon extend from Maine to the Mississippi, &c."

The next notice and very nearly in the wording of the above, is in the Report to Prof. Henry, by Prof. Loomis. Smithsonian Report, 1847.

"When the magnetic telegraph is extended from New York to New Orleans and St. Louis, it may be made subservient to the protection of our commerce, even in the present imperfect state of our knowledge of storms, &c."

See also the "Rural New Yorker" of the following year; also the "Boston Courier" and the "Philadelphia Evening City Item," for 1848 and 1849.

1847. "The extended lines of telegraph will furnish a ready means of warning the more northern and eastern observers to be on the watch for the first appearance of an advancing storm."

1848. "As a part of the system of meteorology, it is proposed to employ, as far as our funds will permit, the magnetic telegraph in the investigation of atmospherical phenomena.... The advantage to agriculture and commerce to be derived from a knowledge of the approach of a storm by means of the telegraph, has been frequently referred to of late in the public journals; and this we think is a subject deserving the attention of the Government."

1849. "Successful applications have been made to the presidents of a number of telegraph lines to allow us at a certain period of the day the use of the wires for the transmission of meteorological intelligence . . . . . . as soon as they [certain instruments, &c.,] are completed, the transmission of observations will commence."

[It was contemplated to constitute the telegraph operators the observers].

1850. "This map [an outline wall map] is intended to be used for presenting the successive phases of the sky over the whole country at different points of time, as far as reported."

1851. "Since the date of the last report the system particularly intended to investigate the nature of American storms immediately under the care of the Institution, has been continued and improved."

The system of weather reports thus inaugurated continued in regular operation until 1861, when the disturbed condition of the country rendered impossible its further continuance. Meanwhile however the study of these daily morning reports had led to such a knowledge of the progress of our storms, that in the Report for 1857, Prof. Henry writes:

1857. "We are indebted to the National Telegraph Line for a series of observations from New Orleans to New York and as far westward as Cincinnati, which have been published in the Evening Star of this city. We hope in the course of another year to make such an arrangement with the telegraph lines as to be able to give warnings on the eastern coast of the approach of storms, since the investigations which have been made at the Institution fully indicate the fact that as a general rule the storms of our latitude pursue a definite course."

It would seem therefore that nothing but the disturbances of the late war prevented our having had ten years ago a valuable system of practical storm warnings. Even before peace had been proclaimed, Professor Henry sought to revive the systematic daily weather reports, and in August, 1864, at the meeting of the North American Telegraph Association (see their published

Report of Proceedings). a paper was presented by Professor Baird, on behalf of the Smithsonian Institution, requesting the privilege of the use of the telegraph lines, and more especially in order to enable Professor Henry "to resume and extend the Weather Bulletin, and to give warning of important atmospheric changes to our seaboard." In response to this communication it was resolved, "That this Association recommend . . . . to pass free of charge, . . . brief meteorological reports, . . . for the use and benefit of the Institution."

On the communication of this generous response, preparations were at once made for the laborious undertaking, and the inauguration of the enterprise was fixed for the year 1865. In January of that year however occurred the disastrous fire which so seriously embarrassed the labors of the Smithsonian Institution for several following years: it became necessary to indefinitely postpone this meteorological work, which indeed had through its whole history been carried on with most limited financial means, and was quite dependent upon the liberal coöperation of the different telegraph companies.

It will thus be seen that without material aid from the Government, but through the enlightened policy of the telegraph companies, and with the assistance of the munificent bequest of James Smithson, "for the increase and diffusion of knowledge," the Smithsonian Institution, first in the world, organized a comprehensive system of telegraphic meteorology, and has thus given first to Europe and Asia, and now to the United States, that most beneficent national application of modern science, the Storm Warnings.

Having been absent from the United States in 1864–66, it so happened that I was not acquainted with the more recent plans of the Secretary of the Smithsonian as above detailed, but rather supposed that its costliness would always prevent the resumption by that Institution of this national work. In May, 1868, on taking charge of the Cincinnati Observatory, I urged in my Inaugural Report, that the practical utilization of the sciences there cultivated should be our constant care, and the desirability of storm warnings was specially indicated. This latter subject was in the same year brought by myself before the Cincinnati Chamber of Commerce, and that body at once decided to authorize me to establish a system of Reports and Predictions, at its own expense and for its special benefit.

"The Weather Bulletin of the Cincinnati Observatory" began September 1st, 1869, the previous summer having been fully occupied with preparations for this duty as well as with the labors incident to the "eclipse expedition" of the Observatory.*

* Accompanied by seven amateur assistants, I occupied the site of old Fort Dakotah, (now Sioux Falls City), Dakotah Territory. A very complete series of

Beginning with ten stations, the number was gradually increased to thirty, from most of which the experienced correspondents of the Smithsonian Institution sent me their morning observations. The dispatches being in a condensed form, allowed me to receive the fullest details, i. e. barometer: dry and wet thermometer; direction and force of wind; weather and rain-fall; kind, amount, direction and velocity of motion of the upper and the lower clouds; and remarks. The Bulletin was published in printed form at first, and subsequently by the "Rogers Manifold Bulletin Process," appearing daily (Sundays excepted), at noon. To it was appended a brief forecast of the weather that would probably be experienced at Cincinnati during the next twenty-four hours.

This was, I believe, the first systematic attempt in the United States to make the weather reports practically useful to our commercial communities. At the expiration of the first three months' trial, and while negotiations were pending with the Western Union Telegraph Company, for its permanent continuance, I, in order to prevent a break in the series, for six months maintained the Bulletin myself, receiving the dispatches gratuitously from the telegraph employées, and publishing the reports daily, including Sundays, in the newspapers of Cincinnati. The reports indeed ceased to include barometric readings, but the number of stations was much increased, and the value of the Bulletin to the general public very frequently acknowledged. In February, 1870, Mr. Armstrong, the enterprising manager of the W. U. Tel. Office in Cincinnati, undertook the daily publication (by the Rogers Manifold Map Process) of a Weather Map for the United States, and this added very much to the value of and interest in the reports. Copies of this map were regularly sent to the telegraph offices in Chicago and New York and elsewhere, everywhere meeting with favor. In May, 1870, the publication of both Bulletin and Map was undertaken by Mr. Armstrong, and continued to be issued by him until in December, when the entire service was relinquished, in view of the daily publications of the Army Signal Office.

I had undertaken this laborious work, in the confident hope that by it a local interest would be excited in the Observatory, which might possibly lead to its being better supported by the friends of science in Cincinnati: and equally had I hoped and expected thus to contribute towards the establishment

observations was secured, but the subsequent year was incessantly occupied with very imperative labors on the Weather Bulletin and a subsequent absence from Cincinnati, so that I have as yet been utterly unable to even attempt the reduction and publication of our observations. By means of a very fine six-inch achromatic and favored by a remarkably clear atmosphere, interesting and novel observations were made upon the corona, of which a brief notice was at once communicated to the editor of the *Astronomische Nachrichten*.

nore extended and ultimately of a national system, such)se that had long been known in Europe. To this end August, 1869, in behalf of the Cincinnati Chamber of nerce, had proposed to the Board of Trade of Chicago a al plan of coöperation by which both organizations would in the advantages expected to result from the Weather tin. That body, however, through a special committee, :red not to engage in such an enterprise, although sensible feasibility, unless the Dearborn Observatory should give weight of its authority and name; but the other duties ofessor Safford seemed to forbid this, and I was forced to) the advantage of such coöperation. An editorial in the go Evening Journal of August 13–17, served, however, to ttention to the Cincinnati enterprise.

November, 1869, occurred at Richmond the annual meet- f the National Board of Trade. Several of the Cincinnati ates (and especially Mr. John A. Gano, President of the nnati Chamber of Commerce) had been the hearty sup- rs of my Weather Bulletin, and were desirous of bringing ıbject to the attention of that body. Their action was, how- anticipated by that of the Hon. C. D. Holton of Milwau- vho presented a memorial, drawn up by the Hon. I. A. am. This distinguished observer, to whom I had for some been indebted for my daily weather report from Milwau- vas perhaps more sanguine than myself of the prospect of diate aid from Congress, and heartily labored to impress nportance and feasibility of storm warnings upon the atten-)f that body. By him was drawn up the memorial pre- l to Congress, Dec. 14, 1869, by Hon. H. C. Paine, and the quent papers printed as Miscellaneous Document 10, (41st ress). This latter paper, as well as the chart of the storm ırch, 1859, published by Professor Lapham in the Chicago ıu, served to very generally arouse public attention. The sity for action was heartily endorsed by prominent Boards ade and Commerce and by eminent scientific authorities. r. Paine is due the suggestion that the conduct of the ser-)e entrusted to the War Department, and it is interesting tice that independently of and coincident with the labors ofessor Lapham, "papers and maps in reference to the subject were prepared in the War Department."

ıgress as well as the country seemed ready for this meas- nd by unanimous consent the following joint resolution romptly passed, receiving the President's signature on the ebruary, 1870:

e it resolved, &c., That the Secretary of War be, and he y is, authorized and required to provide for taking meteor- :al observations at the military stations in the interior of

the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern Lakes and on the sea coast by magnetic telegraph and marine signals, of the approach and force of storms."

By a general order of March 15th, Brevet Brig. Gen. Albert J. Myer, the Chief Signal Officer of the army, was charged with the duty of the execution of the preceding law, and has therefore organized in connection with the Army Signal Office, the "Division of Telegrams and Reports for the Benefit of Commerce."

Washington, May 1, 1871.

ART. XII.—*Infusorial Circuit of Generations;* by THEOD. C. HILGARD.

[Continued from page 25.]

A DIRECT *onward* evolution of Vorticella I had occasion to realize on the fetid scum cuticle of a putrescent aquarium. All the Vorticellæ which, in dense clusters, lined the under surface of that membrane, or animal pellicle, were found to *elongate* into a sort of roughish, but very hyaline, cucumber-shaped form; each "cucumber" at first crowned with a true vorticellan pitcher-mouth, mostly, however, closed and rounded over, occasionally gaping or as it were *yawning* spasmodically, at intervals only, and which finally "shut up" for good. The little glassy knobs—like so many trunk-nails—that covered the surface, grow into soft, jerking-bristles:* the mouth into the well-known mustachioed slit of barbiform *cilia;* and the wan, limpid, empty and now entirely flattened, ligulate or sandal-shaped body tears loose as a young fluttering, pallescent *Oxytricha* (*Pelionella*), or so-called "hackle-animalcule:" *darting* by the jerks of its stiffish marginal bristles, and by the constant "plying" of the long-barbed, ciliate slit effecting its slower progress. It never revolves, but often crawls; (both in contradistinction to the fleeced, revolving and vacuole-propelled "Paramecium" form.

This is probably the "short-line" development, of Oxytricha, directly from the germinal clouds or the parasite of *Chlamydococcus.* through Vorticella. I have no good figures to refer to, since even the detailed ones of Ehrenberg, in Trans. Berlin Acad.

* In their onward development these softish bristles are indurated into "styles" (of specialists). The attentive reader will observe that on such alterations of growth alone, a great many colliding false genera and species have been formed. *Sap. sat.* We have naturally to reject all, of which the *mode* of development remains unknown, as indicating a false standpoint.

.833, Tab. III, figs. II, III, and IV, which belong here (as ıs Tab. XXIV and XXV of A. Pritchard's Hist. Inf., , are too inaccurate to serve as a guide, or to be readily fiable even by those acquainted with the real, natural ;-material itself.

first the bristles of the (tongue-shaped, flat and elongate-.cal) Oxytricha are fluttering and tremulous; but as it and rapidly increases in bulk, all the well-known charac-f the complete "Oxytricha," its stiffish darting-bristles, ımose, obscured body, irregularly replete with granular , and very frequently cross-dividing, become typified. ı thus cross-divided (a process well-known and abundantly ·d) the front part alone retains the barbed mouth, which, the apex, switches down like a moustache on a longitudi-ıt about a quarter of the whole length. The blunt rear-ɔn the contrary, separates with an incurrent angle which contracts into a new mouth; whereby the rear-animal a blunter shape (like the cotyledon of an almond, the flat .ownward).

ɜ Oxytricha is by no means, however, to be considered as ult form, since it is never seen to exhibit a continuity as nembrane, or of internal ducts or viscera. Neither is it to "copulate" or adhere lengthwise, or in any other ›n, to one another, except in the process of self-division. loes it readily divide by longitudinal fission, in this state. e seen this only once. Crawling and darting by an ap-ıs of marginal bristles, prolonged in front and particularly : rear, it is destitute of the "propulsive vacuoles," as found ı the large "*Paramecium Aurelia;*" but, besides being stud-›articularly in the rear portion, with a great number of · and smaller granular *pellets*, its body exhibits near the .e a large, clear and granulate "germinal speck" or *nu-* which is often observed to swell, protruding globularly the surface, below and above, when seen crawling, in a.*

;asionally it is seen to extrude, suddenly, that turgid nal nucleus or yolk (*vitellus*), which, as in all these cases, lf coatless, but hung around with divers jerking molecular .ents, torn loose from the parental body;—which is *rup-on the spot*, but readily "re-cemented," as it were.

e transformation of the "rear-part" of Oxytricha, as given by J. Haime . Sci. Nat., Ser. 3, tom. xix, p. 109 (and represented in Carp. Micr,. p. 447), I have not been able to verify myself; it must not, however, by any be confounded with the *encystments* (1) of Vorticella, producing wafer-like .es; (2) of the non-pulsating, tear-shaped "Paramecium kolpoda" grub, ng free Oxytricha; nor (3) with that of the "oyster" or "porte-monnaie" ›roducing paramecium-like bodies, gregarina-fashion; nor either (4), with ɹrge Oxytricha "currants," containing the revolving "crucible."

The larger of these coatless, granular yolks—(constituting the original *pseudo*-genus, and species "*Zooglœa Termo*" Dujard.")* mostly consist of two parts, viz: a general "albumen" of a granular and evidently *trabecular* texture, enclosing one or two *distinctly coated*, quite hyaline and perfectly *globular vesicles*. The latter resemble in shape a very clear white currant, as it were, by having a sharply defined circlet inscribed near one side, that is caused by a local *inversion* of contents (somewhat like the air-vesicle within a hen's egg).

These "currant"-yolks enlarge in size and soon at the (darkening) circlet, or rim of the introversion, reveal a rapid rotation and "ciliary motion;"—and, still later, a contortion and volubility of contents, really perplexing to the attentive beholder, who in vain attempts to determine its form, or at least to detect it in the moment of hatching, "anxiously wasting whole nights and half days" thereon, as Ehrenberg has expressed himself on a similar subject. At last the membrane bursts and extrudes a globe or halo of gelatine, containing a crucible-shaped body, gently moving, which, when finally set free by the rupture of that gelatinous halo, at once elastically *extruding the inverted part*, takes a shape resembling a rice-palea or the fore-wing of a thunder-fly (Thrips); traveling broad-end foremost with great velocity, and steady as an arrow. After a while a somewhat ludicrous scene ensues, when the little animal, by shedding its fissured skin or scabbard, is seen violently struggling to disentangle its large jerking bristles hidden in the *veins* of the sheath, and its small body. It thus appears like a little dwarf, frantically floundering about in a Spanish cloak, spurs and sword too large for their owner. It now represents a very small Oxytricha with comparatively very long, stout, but as yet softish bristles.

This formed the more *direct* evolution, from the Oxytricha pellet, viz: out of its circular "currant-vesicles." Its enveloping grumose mass of "trabeculated albumen," however, keeps still increasing to the appearance of a loose snow-ball, as it were; and each single trabecular joint assuming a sort of warped §-form, and a jerking spasmodic commotion, they at last tear loose singly, and escape each as a lanceolate, *warped* and finely-tailed "*Vibrio Termo* Dujard."† In consequence of its twisted

* As represented by Cohn in "Nov. Act. Nat. Curios." 1854, Vol. I, Tab. XV, fig. IX. In Klob's microscopic researches on Cholera, the term is mis-applied to engorged joints of dissected corruptive fibrils (or, "Oidium lactis") replete with bacterial daughter-cells.

† The name of "*termo*" (τερμων, a boundary-pole or stake) probably referred originally, rather to the cylindric "battering-rams," extruded from diffluent "currant"-vesicles (or *amœba*) of the paramecian cloud-dissolution, as below detailed. The albuminous Oxytricha-pellet is pretty well represented in A. Pritchard's "A History of Infusoria," tab. XVIII, fig. 69. The indistinct §-shaped (constituent or) developing particles, however, are there technically represented by shading with cross-striæ, conveying a false impression of their shape and structure.

ıpe, it makes its way with a vacillating archimedean motion, ing constantly turned round as it is rushing onward. When out $\frac{1}{200}$ line long, it already clearly reveals the (still warped, t finally flat) *wafer*-shaped body; and the longitudinal *striæ*, *nged with an undulating fleece*, as well as the oblique, ciliate)uth, which also characterize its later stages. From an obıg orbicular pouch-shape, when about $\frac{1}{80}$ of a line, it bemes round like "navy"-beans (up to $\frac{1}{50}$ of a line) only a tle tapering at the upper end; the small oblique mouth being ittle above the middle. The delicate longitudinal striæ all er the body—melon-fashion—give them an iridescent appearce, both under the microscope, singly, and when swarming in asses on the surface, e. g. of aquaria, or of the draining-pans flower-stands. The striæ are apparently set with very soft *ıdulating threads*, resembling wool, nearly half a diameter long, likeness of "ginned" cotton-seed. This feature is absolutely 'erlooked in most of the figures from Ehrenberg up to the 'esent day; otherwise, the former's "*Paramecium Kolpoda*"* ould seem to represent a few of its onward developments.

The body now commences to *bisect*, at first crosswise; becomg *waisted*, *across the mouth*, so that each half has a part of the d one. After assuming the form of an 8, they, after long ruggling and toiling, bisect, often spinning out a long gelatinıs thread (as of a limpid gum) and jerking each other most stily; but after disruption, they presently round off.

In this condition, and the following, the bodies contain one rger and a great many smaller granular *pellets*,—"yolks" or germinal specks," which I have not distinctly seen discharged. ut now the surface of the water becomes clouded with such ·anular balls, of uniform molecules (about $\frac{1}{1500}$ line in thick- ɜss) that likewise germinate into the fragiform clouds, alluded › in connection with Vorticella, etc., and is covered with an)parently amorphous, most delicate but cohesive pellicle (as of)llodion) at the superficial contact with air. All these forms, ; above stated, when caught on a dry surface (e. g. by their ndulating floss), instead of forming into a dry scab, suddenly ecome *liquid* (like fusing lead), with an immense internal comıotion of parts, and bodily dissolve into such cloud-molecules. 'he "wool" itself becomes *quasi*-"dropsical," and each single bril diffluent into a series of such uniform globular molecules, 'hich at first are endowed with an independent motion, vibrioike. Besides this, most of the encystments, moultings and 'olk-extrusions take place under the isolating cover of that niform protoplasm-membrane, which seems to exhale a sort of)ituminous odor (like the fumes of burning flesh, sun-baked carrion, or the rank smell of miry river banks). Membranes, as

* Abhandl. Berlin Acad. Wiss., 1834, Tab. III, fig. 3.

thin but chemically homogeneous organic substances being impermeable to certain gases, while permeable to others, a good deal of physiological interest is involved in the study of this protoplasm-membrane, and its relation to the swamp-gases. The particles of the nubecula are uniformly globular.

After repeated *cross*-segmentations, these undulate fimbriate bodies, always revolving about the long axis (while evidently traveling onward by the action of the *ciliate mouth*) divide *lengthwise*, from below upward; thereby becoming somewhat purse or tear-shaped; the mouth being split in two, so that both stand "plying" mouth-to-mouth, while yet connected at their foreheads, as it were. These finally tear asunder by indentures, after which each has the shape of a crooked glass-tear. When more adult, and about $\frac{1}{48}$ of a line long, the internal yolks and designs have disappeared; the sarcode assumes a uniform yellowish tinge; its mouth forms deep cavities, while its front is toppling over like the hood of an Indian turnip (*Arum triphyllum*) or of a Sarracenia leaf. It now contracts to a globe and encysts. When a smooth, transparent crust is formed, gradually an inward gyration of cilia (as of an enclosed centipede) which ultimately becomes very violent, is observable; and at last the excessive fatigue of watching this tantalizing gyration may be rewarded by seeing the *inmate emerge*, either as quite a large but excessively limber, fluttering and transparent, full-size, single Oxytricha; or else several smaller, mostly narrow, triangular slips)* escape, with the same exceedingly restless volubility; the marginal bristles not yet being stiffly extended in a plane, but ruffled up and down like the bristles on the undulating borders of a thistle-leaf. As they feed and the tissues become scatent, the entire form of an Oxytricha is presently acquired.

I have observed still another development of Oxytricha; its first source, however, being as yet unknown to me. There appear on the field of action numbers of quaint-looking, big-eyed balls, about $\frac{1}{100}$ line thick, snouted, as it were, with a sort of "hair-lip" resembling a duck's bill; the stiff bristles within the bill-shaped mouth quivering with a sort of expressive smirk, and looking altogether odd.

They come full-sized and booming upon the stage, and in this respect argue a direct derivation from certain haw-shaped, five-costate vorticellan buds, with a contracted *pappus* of stiffened cilia around the orifice, spinning and rebounding like humming-tops. The "goggle" now soon becomes stationary, and shortly after, rapidly expanding, and its germinal speck or nucleus (the "eye") particularly enlarging, within half an hour

* The figures L and M, p. 447, in Carp. "Micr." seem to belong here.

psically flattens out into a pretty well-sized Oxytricha,* similar sort of internal fluxile commotion of particles as the animals dissolve into molecular "sauce."

; Oxytricha is not a perfect animal. It has no mem-s, and evidently no fibrous tissues at all. The entire tex-ıpparently remains in an embryonic, *vitelline* condition,

ıave in a single instance witnessed what appeared to be *ıoulting* of a perfect Oxytricha. The front border was vhat removed from the body, which it crowned like the ɔf an ancient helmet, and within each rigid bristle ("style") *thin the fingers of a glove*, was contained the far more te corresponding one of a clear (and now entirely yolk-ɔdied) animal,—the lower quarter being in a like manner n in a part of the old coat. I thought it was plainly identi-.th the following animal, whose development brings us up *Paramecium Aurelia.*" As I have not been able to chance such a moulting process again, I reserve the decision.

ɔlear (internal) animal is apparently developed by this ;ing of the Oxytricha. Of the latter, the very bristles, detached, seem to possess individual vitality, singly beat-bout for quite a while, and even empty coats (apparently sometimes behave as if they had a life of their own. At ents, at a certain epoch there appears at once the next form estion,† in full size, upon the field; the transparently clear s sometimes showing a scalloped border, and alveoli, as *mer* yolks, *extruded*—that soon smooth over. In outline, ıimal appears somewhat like the soft parts of an oyster, flat, somewhat lop-sided, in the shape of a human ear—remost. It is "doubled up" at the straight border, the er lower rim being overlapped, *as by a lid*, with a smaller, ıicker, upper flap ("lorica") containing one clear germinal . This animal *opens like a book*, undoubling its flaps; ; is thus that it devours its prey (such as conferval spawns, by bodily enveloping them like a ray-fish (*Raya*) enfold-ıe nourishment as if *fused around it*, and the whole sur-ɔxhibiting an incredibly rapid ciliary commotion *during hole process of digestion.* This done the cloak again un-often appearing like two stipules, e. g. of a *Liriodendron*, hen closes up again. On drying up, or in search for air *ıoisture*, the animals are often seen to mutually enfold each 's flaps. This cannot, however, be interpreted as a sexual

is somewhat resembles fig. F, turning, by fluid expansion, into fig. E, (Carp. *ibid*). Fig. F, however, requiring to be duck-billed, as it were, and fig. E ɔp-sided and the nucleus more central.

ɪrhaps the "*Euplotes*" of authors. Their descriptions and figures, however, ɔthing that sufficiently resembles this very common form, so as to be readily able.

copulation, seeing that in the first place they neither develop any eggs: nor, in the second place, do they even extrude yolks: but their onward development is *by encystment.*

Within a few minutes such a full-grown "oyster-grub" is seen contracting its big flap, so as to present the shape of a hat with a warped rim and hemispherical crown, the latter formed by the blunter lobe, which contains the "speck" or "eye," and, contracting, gets hemispherically rounded. Very soon (with a constant adjustive quivering of the cilia-like bristles) the whole is rounded into a globe, wherein the doubled inside forms a ciliate hiatus. The latter, soon contracting, closes over. Nothing is now seen but a ball with a clear "germinal speck." In a few hours a *double* contour (the outer one granular is exuded. The speck or "eye" itself now becomes dusky and granular. It increases. It bisects "Gregarina-" fashion. Each pear-shaped segment again acquires a clear speck or "eye." They elongate, being connected by the blunt ends,—each one tapering to a very soft apex; and these very large germs or pseudo-Gregarinas at last become liberated, probably as "*Paramecium Aurelia*," which now appears *full-grown* on the scene.*

It is about the length of the Oxytricha, about three times the length of the revolving wool-fringed grubs of the Oxytricha, and by all means more complexly organized than either. It has the shape of the (shoemaker's) *last* for a very elegant ladies' shoe. From one side it therefore gives the figure as of a foot-print (without the toes); but viewed on edge has a pointed rear end, and in this profile it "takes the name" of Paramecium *caudatum!* The ankle of that "last," however, is beveled away leaving the instep a ridge. Its oral aperture, not clearly distinguishable, is in the middle, slanting almost longitudinally for about one quarter of the length of the body. It seems to work its way, dashing by vacuole-contraction, while at the same time revolving by a roundabout coat or film of short pubescence, almost too delicate to be made distinct. In what appears to be the abdomen it has the well-known circular *pulsatory vesicle*, wherewith it propels itself, and around which point it is often seen spinning like a wheel. A system of fusiform or bulbous vessels radiating around the pulsatory vesicle, contract, as the vesicle expands, and *vice versâ*, as is well-known: and some seem to have several such *pulsatory* "vacuoles." The body is turgid with rather small germinal yolks. These animals I have never seen bisecting either lengthwise† or across, nor copulating sexually. The latter, however, seems to take

* The developmental experiments were made in small parcels, forming a drop (between glass-slips, somewhat held apart) and preserved from exsiccation.

† Ehrenberg's figures, however, show it in that process (if not a mistake).

ıce with the Planariæ, which also show the staghorn-shaped trails analogous to those of the marine (true) Planariæ and .nts of the tape-worm, whose detached individuals are also ıown to hover freely in a liquid, like these Ciliata. It is supsable that the large Paramecium, with pulsatory organs, the young Planaria; but it is certainly not itself an adult ›dy.*

The further and most remarkable of all these progressive .d retrograde developments is the following. The well fed ıd full grown but *entrailless* Paramecium Aurelia becomes slow :d lazy, grayish with the teeming germinal contents, and in a w hours may be seen motionless as the fabulous "Kraken" of ıcient Norway. Its *entire substance* now commences swelling rth into compact, fragiform "germinal clouds;" while a great any of the germinal specks, now become less obscured, are ainly discernible as of the clear, "*currant-shape yolks*" kind. hese in a short time however, commence *moving;* and while ›me of the smaller ones are being propelled by adherent otile granules (probably the "Acineta" *Auct.*), the larger ıes move by contraction, viz: their "circlet" becoming *everted*, .ey now *crawl forth*, like a very limpid *grub*—resembling a ›rt of *tumbling sac!* This "tumbling" is produced by the .ost marvellous facility it possesses of protruding long, blunt ɾanches, (like little stove-pipes) on *any* part of its surface, by ɾersion; so that in a few moments its form is entirely changed. s contents are a visibly and rapidly circulating *so-called* "rotatıg protoplasm," composed of mostly very transparent *individıl vibrionic particles*, partly bulky, but mostly very small. ome dark (red or brownish) vibrionic dots are also dis:rnible.

It now takes the form which has been called "Amœba." his form, however, likewise occurs, when similar yolks or "acietæ," are expelled from *vorticellan* bodies. In either case the tumbling-sac" lastly attains a versatile-campanulate star-shape *ith* "*pseudopodia*," from which break forth volumes of miniıal vibrios, and quite large, cylindric bits of rods, or (*pseudo*)-bacteria." The latter here are thicker than fungine bacteria, ıd are neither coated nor ellipsoidally shuttle-shaped, but luntly cylindric, like cartridges or butting rams. They possess very forcible automatous motion, and like to congregate, and ith great violence keep butting all together, one against the ther, in a heap; and within a few minutes, the whole appearnce has dissolved and passed into a "germinal cloud" of ıolecular "vibrionic" cell-life.

Besides the above circuits of generations, which probably ɔmprise both the pulsatory Paramecians proper (Aurelia)

* Pritchard, etc., figure the planaria-like form as "adult Paramecium."

and the Vorticello Oxy-trichans (through the mediation of the "oyster" or "porte-monnaie-grub"), there occur frequently some *analogous* forms, such as "Kerona" and "Trachelium."

The last form of all to appear in infusions, etc., seems to be the well-known *Rotifer*, the developments whereof are perhaps related to some of those above detailed. It is, however, most probable, according to the observations of Prof. L. Agassiz ("Ann. Nat. Hist." vol. ii, 1850, p. 157), who saw forms resembling the undulate-fleeced ("Paramecium Kolpoda") grubs *bred from the eggs of "Planariæ,"** that such are the adult forms (*if* adult). I have only occasionally met these swelled and pear-shaped, dusky bodies, traveling both back and forward with equal facility, and remarkable for the stag horn-like designs of their *entrails;* thereby evincing something like a membrane in their organization, but the organ being itself of a sort of glandular structure. They are also said to bisect, like the Oxytricha. Some *young* ostensibly planarian forms, larger than Paramecium Aurelia, blackish, and shaped like a short, broad lancet blade, which I have seen "bisecting," did so only while *encysted*, rotating in the manner of mill stones; and the escaping animals had as yet no trace of the visceral organization, as found in the adult Planariæ (and also observably developed in Rotifer).

We are therefore still in doubt as to the true, ultimate genus and species, and therefore have to *suspend* classification; the points of interest, here submitted, being the important physiological processes and transformations on the one hand, and the fallacy of foregone diagnostic terminology on the other. The description of the genetic phenomena of the so-called Fresh Water Algæ, in their *unbroken continuity of developments*, as experimentally ascertained, I reserve for a future paper.

Art. XIII.—*Tornadoes of the Southern States;* by Hampton S. Whitfield, Professor of Mathematics in the University of Alabama.

The tornado is a storm which has two distinct movements, the one progressive along the surface of the earth, the other gyratory, like that of a top spinning on its axis. It whirls as it goes and its force is so great that no structure of wood, brick or stone can stand before it. Even the solid hills quake and the ground trembles beneath its march. Fortunately, its track in this country is very narrow. I have not yet found traces of any one exceeding two hundred yards in breadth.

* This is no doubt what authors figure and describe as the "*adult* Paramecium Aurelia," with its stag-horn shaped intestines and swelled bodies. I am also under the impression that it was *this* form which I had formerly frequently observed in what appeared to be spontaneous *coitus*.

The gyration of the tornado is not horizontal but spirally ɔward, for it not only displaces heavy bodies, but carries them ɔ to a considerable elevation. I have seen a pine tree, sixen inches in diameter and sixty feet long, float out from the ack vortex of one, at the height of a quarter of a mile, and il round, to all appearance, as light as a feather.

In May, 1868, a very destructive tornado originated in the ctensive flats on the Bigbee river, south of Columbus, Miss., ıd crossed Pickens and Tuscaloosa counties, Ala. A few ıys after its passage I visited the wreck of a large, two-story, amed house which had stood in its way, twelve miles east of olumbus. The timbers were scattered for miles along its ıth, and all the family, five in number, were killed. Their ɔdies were found at some distance from the site of the house, ıe nearly a quarter of a mile away on the next hill. The othing of the females was stripped from their bodies. The ont portico of the house rested on a single piece of pine sixen inches square and fifty feet long. There were no timbers amed into it and it was, therefore, moved by the force acting ıly on its own surface. It was carried across the intervening ılley to the adjacent hill, into which it plunged end foremost, ɔening a deep trench. Here it shivered, and leaving a short agment, passed on. Lying on the ground, under the portico, as a solid iron shaft, an inch and a half in diameter and eighing sixty pounds. It was transported more than a hunred yards.

To produce such results required a pressure of at least one ɔund to every square inch, a force fearful to contemplate as ossible for the wind. Some idea can be formed of it when we ɛflect that this house, being fifty feet long by twenty-five in eight, presented a front area of one hundred and eighty thouınd square inches, and therefore encountered a pressure of inety tons. The velocity of the wind, necessary for such an ffect, must have been one hundred and sixty miles per hour. ɩet it be taken for granted that this velocity was at the point of reatest energy in the gyration, for it must have a point of reatest and one of least effect. The point of greatest energy r effect on stationary objects is on that side where the direcıon of gyration coincides with that of progression. Should the dvancing speed of the storm just equal the velocity of rotation, hen on one side the effect would correspond with the sum of hese velocities, while on the other it would be entirely neutralzed; for, on this side, the wind would move backward as fast s the tornado would go forward.

It is impossible to determine accurately the average speed of ur tornadoes, but careful observation and comparison have led ıe to fix upon forty miles per hour as very near the truth.

This must have been about the rate of one whose formation and progress for several miles I witnessed, but the spectacle was so absorbing that I entirely forgot to time it by the watch. On another occasion, in the night, I listened, in company with several others, to the roar of one passing at the distance of two miles, and we all agreed upon forty miles as about its rate.

In May, 1840, a part of Natchez was destroyed by a tornado, the most dreadful that has ever passed through the Gulf States. It crossed the river at two o'clock, P. M., and at 9 o'clock burst upon west Alabama in the shape of a rain storm, pouring unprecedented torrents. Its rate was, therefore, about forty miles. The Pickens county tornado, if the accuracy of two witnesses, fifty miles apart, can be relied on, exceeded this rate a little. For the sake of analysis let forty miles be taken.

The progress of tornadoes is always, in the Southern States, from a point south of west to a point north of east, and, although sometimes varied by prevailing winds, this direction is characteristic and due, as I shall show, to the rotation of the earth on its axis. The gyration is always from right to left, and this, also, as is known, is an effect of the earth's rotation.

On the south side of the tornado, then, the greatest power is exhibited, for here the gyration is forward or coincident with the translation, while on the north side the gyratory motion being contrary to the progression, the effect is least. At the front and rear, where the gyration crosses the path, the effect must be the same.

Suppose, then, that the velocity of gyration is one hundred and twenty miles per hour. Add forty, the speed of progression, to the south side, and the velocity of impact, against stationary objects, would be one hundred and sixty miles per hour. Subtract forty on the north side and it would be eighty. Now, wind moving eighty miles an hour will not necessarily throw down trees and wreck buildings, but at a speed of one hundred and twenty or one hundred and sixty miles, it will level all obstructions. The most destructive energy, then, is developed in the south semi-circumference of the whirl, and the diameter of the gyration must be, in most cases, much greater than the apparent path. The aspect of the wreck along the path of these storms is in conformity with the above analysis of forces. Where they traverse forests, by far the greater number of trees are thrown eastward, and nearly parallel to the line of progression some fall northward and some southward but none lie backward parallel to the track. The framed house in Pickens county stood in the southern rim of gyration and all its fragments, together with its inmates, were carried eastward.

One of the most remarkable accompaniments of the tornado is the black column or spout, extending from the cloud down

to the surface. It precisely resembles a column of black smoke, such as pours from the pipes of a steamer burning pine wood; it is in fact condensed vapor or cloud, intensified in blackness by the dust and rubbish carried up from the ground. The tornado is a shell or hollow cylinder of air, and all its energy lies in its rotating rim which is powerfully compressed by two antagonistic forces, centrifugal and centripetal. The rapid whirl draws the air from the center toward the circumference where it is met and opposed by the in-rushing winds. There is, consequently, a rarefaction, a great reduction of temperature by expansion, and condensation of vapor within the shell.

The spout does not hug the earth continuously, but rebounds or *ricochets* along the uneven surface, often skipping the valleys but generally desolating the hills. It is disposed, however, at every recurrence to strike at the same points. It is not an established fact, but it is commonly believed, and with some reason, that the tornado does, in the course of years, return along its beaten path, and that it is unsafe to build where one has ever passed. The house in Pickens county stood on a hill from which a log cabin had been blown away some thirty years before. I witnessed the last of three, which have passed along the same track. Near Hernando, Miss., three have followed an unvarying line. It is probable that there are some localities more favorable than others to the generation of these storms, and if this is true, then the law of direction, hereafter explained, accounts for their progress along the indicated path.

Such an opportunity, as fell to my lot, of witnessing the formation and course of a tornado is rarely enjoyed, and the phenomena observed on that occasion are of great value in illustrating the origin of these whirlwinds. On the 29th of April, 1867, at 10 o'clock A. M., I was approaching Tuscaloosa, on the Elyton road, the general direction being east and west. The weather was hot and oppressive, while a perfect calm prevailed both at the surface and in the upper regions, for the leaves were not stirred upon the trees and the heavens were covered with fragmentary clouds, perfectly at rest. Occasional large drops of rain fell, and there was, now and then, lightning. The atmosphere was evidently surcharged with vapor and in a condition of great electrical excitement. At the distance of three and a half miles from town, an elevated ridge, over which the road passed, afforded an extended view, and I saw a mass of black cloud, detached and hanging over the western horizon. It appeared nearly circular in shape with the exception of a slight angular projection, like an inverted cone, at its lower edge. I afterwards ascertained that it was at this time about five miles distant from me, and a calculation, based upon the estimated angles, fixed the elevation of its base above the sur-

face at about fifteen hundred yards, and its diameter, considering it a sphere, at about six hundred. It was entirely at rest.

The first view of this cloud suggested to me the possibility of a tornado, and I watched it closely as I drove along in my buggy. While I was driving, leisurely, more than a quarter of a mile, it maintained its position and outline unchanged. At length a farm house with its shade trees intercepted the view for about a minute, and when I came again in sight of it, the projection beneath the cloud appeared in violent commotion. There was now no longer any doubt of the character of the phenomenon about to be exhibited, and satisfied, from a knowledge of the general direction of tornadoes, that it must come near me, I leaped from the buggy and released the horse as quickly as possible, in order to give him a chance for his life. This did not occupy more than a half a minute, and when I turned to look again, the black column was formed, reaching from the cloud to the ground. A few moments showed that it was rapidly approaching. I remember noticing small fragments of cloud moving toward it from the north, but there was no perceptible breeze where I stood. When about a mile distant I saw that it would go south of me, and at this time I first observed the surface drift, which appeared like an innumerable flock of birds, flying around the summit of the column, and here, too, the pine tree spoken of emerged from the vortex, and settled slowly to the earth. The column was now much shorter than when first formed; the cloud had descended much nearer the surface. It passed about three hundred yards south of my position and at this point the first electric discharge took place. The lightning zigzagged down the column, shedding through it a lurid glare. The roar was deep-toned and powerful. The gyratory motion was distinctly visible. When a little further on, it became so enveloped in clouds as to be no longer distinguishable, but I knew, by the now frequent peals of thunder, that it was increasing in violence and levelling all things in its path.

This tornado was formed about a mile and a half southwest of Tuscaloosa, over an extensive marshy flat, where an observer characterized it as a "big whirlwind." It was not destructive at first but grew in energy as it progressed, and two miles from its starting point, threw down a dilapidated building. About six miles from Tuscaloosa it struck a log cabin in which were sitting a woman and several children. Every log above the floor was carried away, while the occupants were left uninjured. Twelve miles further on it performed a similar feat, taking off every log of a house without the slightest hurt to any of the family, all of them having taken refuge within on its approach. This is remarkable, but there are other like instances well au-

henticated, and it is commonly believed that a log house is the afest retreat. The direction of this tornado was east by 20 egrees north. After its passage the air was cool and pleasant, nd, at 4 o'clock in the afternoon, heavy rain came from the orth, followed, for the next few days, by clear weather with orthwest winds.

The most remarkable fact, disclosed by the phenomena of his storm, is the inherent power of progression which it unuestionably possessed. After the gyration was established it egan at once to travel eastward, not driven by any wind, but loughing its own way through the tranquil atmosphere with remendous speed. Here is presented a problem, which, so far s I know, has not heretofore been propounded. Its solution s important to the science of meteorology. The fact that toradoes invariably move from the southwest to the northeast is rell established, as also the fact that, by an impulse acquired rom the earth's rotation on its axis, they gyrate from north by rest to south. This backward gyration is thus explained: All arallels of latitude decrease in diameter, and therefore in cirumference, as we go toward the poles of the earth. As they ll revolve in twenty-four hours, it follows that every one, aproaching the pole on either side of the equator, moves around nore slowly than the one preceding it. Therefore, a current noving southward, to the vortex of a tornado in the northern emisphere, finds that vortex rotating eastward with a superior elocity, and is left behind, or, projected to the west, while, for he same reason, a current blowing northward to the vortex, nds it rotating with inferior velocity, and, preserving its own asterly momentum, is hurled forward or projected to the east. Thus the south half of the rim being impelled eastward, and he north half westward, the backward or left-handed gyration s fixed and maintained. Just the reverse is true in the southern emisphere of the earth, while on the equator the gyration rould be free to take either direction

Espy denied the whirl of tornadoes, while Redfield, another minent writer on the subject, maintained it. The question as, I believe, long been settled in favor of the latter.

I now propose to show, also, that the translation of tornadoes rom west to east is effected by the earth's rotation on its axis. But, as this proposition is in conflict with the theory of cause nd formation, as enunciated by Espy, and supported by the igher authority of Loomis, it will be better to state briefly hat theory.

"Storms," says Loomis, including tornadoes, "are caused by a strong and extensive upward motion of the air, by which means its vapor is condensed by the cold of elevation." To epitomize his language, the rays of the sun heat the surface of

the earth without heating, except slightly, the atmosphere through which they pass. The surface warms the air near it, while, at the same time, radiation more easily takes place from the superior strata, thus reducing the temperature of the upper regions. Since air expands and grows lighter with increase of temperature, and contracts and becomes heavier from diminished heat, it follows that, under this influence, "the atmosphere is in a state of unstable equilibrium, *and the lower strata tend continually to rise and take the place of the upper.*" The ascending air, coming under diminished pressure, expands, and therefore cools. At a variable height, depending on the dew point, or the quantity of vapor, the cooling causes condensation or cloud. Condensation of vapor sets free latent heat. This liberated heat warms the surrounding air and causes it to ascend higher. Another expansion takes place, followed by another cooling, another condensation, and another liberation of latent heat, and so on indefinitely, or until all the vapor held in suspension is disposed of. Thus dense clouds of great depth are formed, and rain, hail or snow, two, or all, result. The ascending column is continually fed by surface currents converging to the center, and the violence of the storm is in proportion, as Espy says, to the "steam power" of the air; that is, the amount of vapor suspended in it.

Olmsted, in a lecture on Espy's theory, has, I think, shown that this process of alternate cooling and heating is impossible. The truth is, that the liberation of latent heat simply serves to retard the too rapid condensation, and without this check the violence of storms thus produced would be tenfold greater.

There can be no question that rain is caused in this way. The piled-up clouds, called *cumuli*, so common in summer, are produced by ascending currents, and from them result ordinary summer showers, but there is a vast difference between the summer shower and the tornado; so great, in fact, that we are compelled to attribute them to entirely different modes of generation.

In quoting Loomis, I have italicized one sentence. Owing to the "unstable equilibrium," caused by surface heat and radiation above, he says: "*The lower strata tend continually to rise and take the place of the upper.*" Here he has stated the effect for the cause. The fact is, that *the upper strata tend continually to descend and take the place of the lower.*

Espy, endeavoring to establish a favorite theory, makes the quite untenable assertion "that the air of the upper regions is specifically hotter than the air at the surface;" which means, if it means anything, that a pound of air in the upper regions contains absolutely more heat at a given temperature, than a pound at the surface. All this belongs to a philosophy which has been long since exploded; and in fact, every sound philoso-

her must at once perceive that, under such conditions, no cur-
ents could either ascend or descend; the "specifically" hotter,
id therefore lighter air, at the top, could not possibly come
own, because it would become *sensibly* hotter, and therefore
ghter than the air below; and the "specifically" colder air at
ie surface could never rise, for a corresponding reason. An
unstable equilibrium" could not exist. My prescribed limits
rbid a more elaborate discussion of this point.

If an "unstable equilibrium" exist, the upper strata will
end to sink, and *a descending current must necessarily produce
n ascending current.* Again, the "unstable equilibrium" re-
uires that the air from the upper regions, when it reaches the
irface, should, notwithstanding its compression, be colder than
ie surface air, or else it could not undermine and force it up.

This descending current may be a contracted column, pouring
own rapidly, or it may be the entire body of the atmosphere set-
ing slowly over a wide area. The latter process goes on where
iere is any local cause of heat, as in the case of fires, and the
xpanded column is pushed up by the surrounding air pressing
pon its base. The former takes place, under favorable circum-
ances, when a great expanse of air is heated up uniformly at
ie surface. Here the descending stream is a rapid spouting
olumn, and the ascending one a slow compulsory uprising of
ie whole body of surrounding air. In this case, if the tem-
erature of the falling air is below the dew point of the lower
rata, condensation takes place and cloud is formed. If the
ifference is very great the down-moving current will be very
owerful, and the centrifugal force resulting from its gyration
ill generate an immense vacuum or vortex, into which the air
om beneath will rush violently, forming a secondary vortex,
hich is the spout of the tornado. Should the ascending cur-
ent fail to concentrate into a spout, the storm is known simply
s a hail-storm. These differently named movements have a
milar origin, and present similar phenomena. Nearly every
rnado exhibits hail, and nearly every hail-storm, at times, a
out. At a considerable elevation the descending column,
efore it is compressed to any great extent, is icy cold, and, by
xpansion in the vortex, its temperature is reduced ten fold, so
iat the vapor of the air rushing in from below is instantane-
usly frozen.

The tornado is, then, a tremendous maelstrom in the atmos-
here. Its vortex, extending possibly to the utmost limits of
he air, and widening out at the top, involves a vast extent of
he upper strata in its commotion, often giving raise to rain
torms and secondary tornadoes many leagues distant from its
path. Its prodigious force is due to the concentrated momen-
tum of all the currents moving to the common center; is the

sum of the forces of all the centripetal streams set free in a contracted area.

It is a well-established fact that tornadoes are translated from west to east. It is also admitted that they are generated in a calm atmosphere. It is, therefore, surprising that Espy and other advocates of the "ascending column" theory, did not perceive that their storms must, unavoidably, be translated in the opposite direction, or from east to west. As the earth rotates to the east, carrying the atmosphere along, it follows that the greater the elevation or distance from the axis, the greater must be the velocity eastward. Hence, an ascending column, penetrating the upper and more rapid strata, is left behind or projected to the west. Overlooking this principle, however, they assign as the cause of the direction of tornadoes an elevated and constant eastward wind, maintaining that it seizes the top of the tornado and drags it as a ship drags its anchor. But there is no cohesion in æriform columns, as in cables, and it is, therefore, impossible for a force applied at the summit to pull the base along. Espy contradicts his own theory frequently by asserting that the tops of rising columns, forming cumuli, are "shaved off" by upper currents. It is very evident that if a strong wind from the southwest should be blowing at a great elevation while a tornado, formed according to Espy's theory, is raging in an underlying calm, the earth's rotation would carry the storm westward, notwithstanding the contrary wind above, for this would simply "shave the top" and bear it off, while the storm went on the opposite course.

There is but one way in which an elevated current can affect the direction of a tornado, and that is *by descending into its vortex*. In this mannner only can it communicate its own momentum and control the path, and in this manner it often does produce a great variation from the normal line. Neighboring winds, bordering the calm in which the storm originates, may also, in a way easily explained, cause a deflection.

It has been shown that a column of air ascending in a calm must be deflected to the west by the earth's rotation. For the same reason one descending must be impelled eastward. Tornadoes always travel from west to east in obedience to this law.

The process of formation is now easily comprehended. In an atmosphere supersaturated and unduly heated at the surface, let a calm prevail over many miles of territory. The equilibrium is powerfully disturbed. A great volume of elevated air begins to settle down, forcing up the lower strata. In descending it meets and mingles with the warm, moist air beneath, forming cloud. Whatever latent heat may be evolved by condensation is at once reabsorbed by accessions of cold air from

above. The descending stream, fed by oblique tributaries from all points of the compass, begins to gyrate. From centrifugal force result rarefaction, cooling, and further condensation. The center of the vortex is a partial vacuum, and from below a column is drawn up into it. This ascending column also takes on gyration, and the tornado spout is created. But this spout, the effect of which is so terrific, is nevertheless secondary and incomparable to the tremendous commotion of the great whirl above. The two columns meeting, vast volumes of air are thrown off by centrifugal force in all directions, and the cloud expands and enlarges with amazing rapidity. This expansion is often mistaken for the progression of the storm; the cloud appearing to approach one observer from the northwest, perhaps, while another sees it rolling up from the south. In the meantime the descending stream has pressed the cloud down upon the surface, where it envelopes everything along its path in almost total darkness. At length the superior vortex becomes so great in diameter that the spout is disrupted or so diffused as no longer to exhibit the concentrated power of the tornado. The whirl becomes co-extensive with the overhanging cloud, and the meteor is now a rain or hail storm of tremendous violence. The tornado of April, 1867, near Tuscaloosa, raged as such for about thirty miles, when it lost its distinctive feature, the spout, and poured such torrents as to cause a great freshet in the Warrior river. It has already been stated that the Natchez tornado expended itself in a tremendous rainfall, and this is the termination of all these storms. They are of variable duration and extent, continuing until the equilibrium of the atmosphere is restored.

Loomis has explained, but not to entire satisfaction, the cause of the northward inclination of tornadoes. He rightly ascribes it, however, to the decreasing diameters of the successive parallels of latitude. If a tornado should form on a parallel of 45 degrees, its vertical axis would make an angle of 45 degrees with the earth's axis of rotation. It follows, then, as would readily appear from a diagram, that the currents descending obliquely to the vortex on the south side, would approach the earth in a direction more nearly perpendicular to its axis than would those descending on the north side, for the latter would be more nearly parallel to the earth's axis. Then, by reason of the earth's rotation, the eastward impulse of these southern currents would be greater than the westward impulse of the northern currents. The deflection of the former would be greater than that of the latter, and, consequently, velocities corresponding, there would result a greater centrifugal tendency on the northeast than on the southwest of the vortex; and the effect increases with the latitude.

This will plainly appear from a diagram. Let a circle be described representing the rim of a tornado. Then let two lines be drawn, one representing the resultant of the forces of the southern currents, and the other the resultant of the forces of the northern currents, each deflected as it approaches the vortex, but the former more than the latter. Each will maintain its influence, from its point of contact, around to the point where the other impinges, and that from the south, having the greater impulse, and, acting on the northeast semi-circumference of the rim, will press the storm northward.

The process of hail-formation takes place in the great vortex above the base of the cloud, probably at considerable elevation. There the gyration, not impeded as it is at the surface, presents a vast and rapid whirl, the centrifugal force of which causes extreme rarefaction, accompanied with intense cold at the center. The saturated air carried up into it from below, by the spout, furnishes the material for hail. Congelation follows instantly upon condensation, and the stones, tossed about in every direction, are finally thrown out upon the circumference, where they are free to fall.

Electricity, which has been supposed to play an important part in the generation of tornadoes and hail storms, is but an effect. It is excited and set free by the condensation of vapor, and is developed in proportion to the amount and rapidity of cloud-formation. In the Tuscaloosa tornado the gyration had formed and travelled three-and-a-half miles when the first flash occurred.

The tornado may be looked for in the winter and spring months, during the prevalence of southern winds. As stated above, a descending column requires, as a prerequisite, a surface stratum uniformly heated over a wide extent. As the sun advances north, after the winter solstice, the south winds that reach us blow from low latitudes on the Gulf. They have then, not only abundant moisture, but a temperature higher than is due, at any time before June, to the effect of the solar rays in our own latitude, and therefore answer the necessary condition of a stratum heated uniformly over a large area. Our tornadoes consequently do not grow out of the heat rays that penetrate our latitude, but rather from the heat of the tropics, transported hither in the winds; and this is the reason of their appearance either in the daytime or night. We never witness them in the hot summer, because then the lower atmosphere is warmed by direct rays, and a uniform temperature, over a wide extent, is impossible, from the fact that the cleared lands and forests, hills and valleys, are heated unequally, giving rise to ascending columns and moderate storms. If the theory of Espy were true, then July, August, and September

would be the tornado season with us, for in these months moist south winds blow, and the sun's rays are most powerful.

The cause of the greater violence of storms produced by descending air is not difficult to comprehend. When a downward column becomes well defined, it is fed, as before suggested, by tributaries flowing obliquely down from all sides. The very top of the atmosphere sinks freely into the stream. The case is precisely that of a heavy body descending an inclined plane; but the heavy body is here a great ocean of air superimposed upon another abnormally elevated in temperature, and therefore abnormally rarefied. The tornado is a process by which the one seeks to settle beneath the other, and is not unlike what would occur should an opening be made through the bottom of some great reservoir of water.

On the other haud, when the transposition begins in consequence of the movement of a definite column, ascending from below, the earth's surface presents a limit, and the tributaries cannot, as in the other case, flow obliquely in straight lines without leaving a vacuum beneath, and that is impossible. They must, therefore, though ever seeking to mount upward, still trail along the surface until they converge at the center. An impediment of this nature would find adjustment in many uprising columns of limited power, capped with cumuli and resulting in showers, but no one vast, absorbing vortex, could monopolize the whole movement, and shake the firmament with its might.

The effects of the tornado are often, to all appearance, very anomalous and extraordinary. It strips the feathers entirely from fowls when the gust strikes them from behind. In a row of buildings in a line with its direction, it may throw down the middle one, and leave the others standing. This is possible when they are located on the central line of progression, for then the blow is delivered by the front and rear of the rim, gyrating at a right angle with the row, and every house must stand or fall, according to its own power of resistance. Or, if a firmly-built house withstand the outward shock, it may yield to the elastic force of its inclosed air, expanding, as it must, with a sudden and powerful effect, that instant the vortex, which is a partial vacuum, passes over it.

Again, pointed pieces of wood or iron pierce or penetrate wherever they strike end-foremost, and pebbles are imbedded in soft wood by the force of the blast. This is not so remarkable when we reflect that the velocity of gyration is three hundred feet a second—and it may go far beyond that—which is greater than the speed of an arrow shot from a bow. On the track of the Pickens county tornado a rafter of a house was found driven through a pine tree.

The whirling sand storms of the desert are probably tornadoes without the accompaniment of clouds with thunder and lightning. The great desert of Africa presents an uninterrupted surface of sand to the sun's rays. The lower strata over its broad expanse are heated uniformly, and this first requisite is answered. But the dryness of the air fixes the dew point at an extremely low degree, and there can consequently be no condensation or cloud. Yet the vortices may form as in other localities, and vast quantities of sand take the place of cloud.

My information is too limited, however, to justify any positive theory in regard to these desert storms. I merely conjecture that they are formed like the tornadoes of our States, but that, unlike them, they are generated from direct heat rays absorbed by the surfaces immediately under them, and therefore appear generally in the daytime, and in the summer months, as well as at any other period.

ART. XIV.—*Preliminary Notice of New North American Phyllopoda;* by A. S. PACKARD, JR., M.D.

THE following brief descriptions are extracted from a monographical notice of our Phyllopod Crustacea, which, with the exception of the Branchipodidæ, so thoroughly investigated by Prof. Verrill, have been sadly neglected. It will be noticed that North America is rich in the species of Apus, more so than any other quarter of the globe so far as yet known. It is a little singular that no species has yet occurred east of the Mississippi river. The species of Limnadiadæ are probably more abundant than naturalists are aware of, and the attention of collectors of shells is called to these Cyclas-like shelled Crustacea, whose shells may not infrequently be mistaken and passed by as simply species of Cyclas. For the privilege of studying the species of Apus I am indebted to Dr. William Stimpson, who has loaned me the specimens placed on deposit in the Chicago Academy of Sciences by the Smithsonian Institution, and to Prof. A. E. Verrill, who has contributed the specimens in the Yale Museum; while the Museum of Comparative Zoology at Cambridge has contributed a new Apus from northern India, and for the Limnadiads my acknowledgments are due to Mr. G. W. Belfrage, an industrious collector, and Prof. E. S. Morse, who have given several species to the Peabody Academy of Science.

APODIDÆ.

The known species of Apus may be for convenience divided into three sections, characterized in part by the length of the

shield, or carapace, the highest forms having the shortest carapace, those with the longest shields, as the European *Apus cancriformis*, approximating in this and other characters to the genus Lepidurus.

Section *a* comprises *Apus longicaudatus*, *Lucasanus*, *Newberryi*, and probably *Domingensis*.

Section *b* comprises *Apus æqualis*, and *Guildingii*.

Section *c* comprises *A. cancriformis* and *Himalayanus*.

Apus longicaudatus Leconte, Ann. N. Y. Lyceum.

Prof. Dana's type specimen, which is now very imperfect, was labelled "Rocky Mountains, near Long's Peak." Four specimens from "Texas, J. H. Clark, No. 3." Three specimens from "pools near Yellowstone river. Dr. Hayden, No. 6." Mus. Chicago Acad. Both sexes occurred, the females having eggs. James's *A. obtusatus* (Long's Expedition) is probably this species. *A. Numidicus* Lucas, from Algeria, in the form of the carapace seems to be allied to *A. longicaudatus*.

Apus Lucasanus, n. sp.—♂ closely allied to *A. longicaudatus*. The frontal doublure rather longer than in *longicaudatus*, and hypostoma a little smaller. Maxillipeds shorter and smaller, and telson longer than in the preceding species, with three median spines above. Anal stylets less spiny.

No. of segments behind posterior edge of shield 33; no. behind the last pair of gills (including telson) 13; length of body (excluding caudal stylets) ·94; of carapace along the middle ·37; total length of carapace ·48; length of tergal carina ·24; distance from anterior end of carina to front edge of carapace ·16; length of caudal stylets ·57; being a little over half the length of body; breadth of shield ·40 inch.

Six specimens in a bottle labelled "Kansas, No. 5," and containing thirteen ♀ *A. aequalis*. Mus. Chicago Acad. They cannot be distinguished from St. Lucas specimens.

♀, carapace longer than in ♂, and caudal stylets not so heavily spined. No. of segments behind posterior edge of shield 29; no. behind last pair of feet 11; length of body ·80; of carapace along the middle ·30; total length of carapace, ·40; length of tergal carina ·25; distance from front end of carina to front edge of carapace ·16 (stylet broken); diameter of egg-sacs ·09 inch.

One specimen from "Cape St. Lucas, John Xanthus, No. 4." Mus. Chicago Acad.

Apus Newberryi, n. sp. ♀.—This fine species differs chiefly from *A. longicaudatus* in the shorter maxillipeds, and much longer, smooth telson with 3 instead of 4 median spines, and in the smooth, finely spinulated caudal stylets, while the carapace is longer. No. of segments behind posterior edge of carapace 29; no. beyond last pair of feet 11; length of body 1·78; of

carapace along the middle ·75; total length, 1·00; length of tergal carina, ·50; distance from front end to front edge of carapace ·30; length of caudal stylets, 1·05 inch.

Two specimens from "Utah, J. S. Newberry, No. 1." Mus. Chicago Acad.

A. æqualis, n. sp. ♂.—In this species the carapace is much longer than in the preceding species, the eyes are larger, the tubercle behind them is smaller, and the gills reach much nearer the telson.

No. of segments behind posterior edge of shield 28; no. behind last pair of feet 11; length of body 1·15; of carapace along the middle ·56; breadth ·56; length of tergal carina ·65; distance from front end of carina to front edge of carapace ·21; length of caudal stylets ·75 inch.

Two specimens from "Matamoras, Mexico, General Couch." Mus. Chicago Acad.

♀. The telson has 5 median spines and is shorter, and the stylets have more numerous and shorter spines than in *A. Newberryi*. The under side of the telson is much smoother than in *A. longicaudatus*, and the outer gill of the 1st maxillipeds is a little longer and more acute. No. of segments beyond the hind edge of carapace 25; no. beyond the last pair of feet 9; length of body 1·07; length of carapace in middle ·56; breadth ·46; length of carina ·33; length from front end of carina to front edge of carapace ·23; length of caudal stylets ·75; diameter of egg-sac ·24 inch.

Thirteen specimens from "Matamoras, General Couch" and "Kansas No. 5," Mus. Chicago Acad., and a specimen from Yale Museum labelled "Plains of Rocky Mts., no. 390."

Apus Guildingii Thompson, Zool. Researches, Jan. 1834, p. 108, belongs to the same section of the genus as *A. æqualis*, but the 4th branch of the 1st maxillipeds is longer than in any other species known to me, being represented as reaching almost to the end of the caudal stylets. St. Vincent, West Indies.

To the third section of the genus belongs the European species *A. cancriformis*, and the following species from North India. They differ from the North American species in the longer carapace, the smaller eyes, and round postorbital tubercle, the less spiny telson, the more hairy caudal stylets, and the larger hypostoma.

A. Himalayanus, n. sp. ♀.—Frontal doublure and hypostoma as in *A. cancriformis*; the first pair of maxillipeds are of about the same length as in *cancriformis*, but the joints are more numerous and smaller, there being 80 joints in the longest branch, while in a specimen of *cancriformis* four times larger, there are 50. The telson is longer than in *cancriformis*, but the number and arrangement of the spines is the same, as is the

under side. The stylets are scarcely as long as the body, while in *cancriformis* they are considerably longer, and the fine spines are a little stouter. No. of segments beyond the hind edge of carapace 19 (in *cancriformis* 19); no. behind last pair of feet 7 (in *cancriformis* 6); length of body 1·00; length of carapace along the middle ·64; length of carina, ·45; distance from end of carina to front edge of carapace ·36; length of caudal stylets ·95; diameter of ovisac ·15 inch, ovisacs situated on the 11th pair of maxillipeds as in all the other species of the genus known to me.

"Collected from a stagnant pool in a jungle four days after a shower of rain had fallen. For five months previous to this rain there had been no rain upon the earth. Himalaya Mountains, North India, near where the Sutlege river debouches into the plains. April, 1870." Mus. Comp. Zoology, Cambridge. Two specimens.

Branchipodidæ.

Streptocephalus Texanus, n. sp.—The male differs from *S. similis* Baird, from St. Domingo, to which it is otherwise closely allied, in the longer branch of the inferior antennæ being much longer and slenderer at tip (according to Baird's figure), while the shorter branch is much narrower. In the female the ovisac reaches to the penultimate segment of the abdomen, while according to Baird's figure it scarcely reaches to the end of the 4th segment from the end, and the second antennæ are represented as being much larger than in our species. The male organs arise from the 8th segment from the telson, and the 15th of the body; and are simple, unarmed, slender, cylindrical, very long, and curled around (in alcoholic specimens) so as to touch at their insertion. Total length, male, ·65; length of longer appendage of 2d antennæ ·17 inch; caudal stylets ·13; length of male organs when extended ·13. Female ·55 long, caudal stylet ·11; ovisac ·20 inch. "Waco, Texas. Found in the summer in the same pool as the Limnadia was taken. The pool was formed by the summer rain, and as it had passed a considerable time in a dry condition, I suppose this species appears much later, or at least not at the same time as the Limnadia." G. W. Belfrage. It also occurred in April, the females having eggs, as did those found in the summer of the year previous.

Limnadiadæ.

Limnadia Texana, n. sp.—Eyes double, but with the inner edges contiguous; pyriform tubercle behind them one half as large as the eye-bearing prominence; ·20 segments behind the fore-head, including the telson; 15 pairs of feet. Antennæ with 8 joints on each branch, the 7th and 8th joints subdivided each into two subjoints; the setæ slightly plumose on the basal

joints. Telson with 16 fine teeth, not including the terminal acute spine. Caudal lamellæ long and slender, cultriform; under edge slightly curved, fringed with long hairs, those at the base slightly plumose; the upper edge straight; end blunt. Carapace valves rounded oval, pure white; 5 lines of growth; shells minutely dotted, the markings being coarser at the posterior end of the shell, and about the region of the adductor muscle. Length of shell ·27; breadth ·16 inch. It is much longer and narrower than *L. Americana* Morse, and with a less number of lines of growth, the latter having 18; in this respect it is much nearer *L. Hermanni* of Europe, though the shell is much narrower. Compared with Baird's figure of *L. antillarum* from San Domingo, to which our species is nearest allied, the shell is more rounded ovate at each end, being somewhat truncated. While the ends of the caudal stylets are said in *L. antillarum* to be "somewhat curved, sharp pointed and slightly serrated on upper edge," the tip in our species is blunt, smooth on the upper edge, and ends in a slight hook. *L. antillarum* is also said to have joints to the rami of the 2d antennæ, and 18 pairs of feet.

One specimen, Waco, Texas. "Quite common in many places in western Texas in the early spring. It occurs in muddy pools made after rains, and totally disappears with the first drying of the pools. As far as I have seen they are only found in the woody bottom lands and always near creeks. It occurred in the same pool as Streptocephalus." G. W. Belfrage.

Estheria Belfragei, n. sp.—Rami of the anterior antennæ with 16 joints, 17 pairs of dorsal spines exclusive of those on the telson, which are 15 in number (in *E. Mexicana* they are much more numerous) and the middle one is much larger than those near it. The spines on the telson are fewer in number and larger than Claus represents in *E. Mexicana*; caudal stylets longer and slenderer than in *E. Mexicana*, and the terminal spine is longer and slenderer, judging from Claus' figure.

Carapace valves with the umbones situated at the anterior third of the shell; dorsal edge straight behind the umbones, slightly serrate, bent rather suddenly downward at two-thirds of the distance from the umbones to the posterior end, the end being full and rounded; anterior dorsal edge slopes rapidly from the umbones, and the anterior end is full and convex. Umbones prominent and rather acute, but not oblique. About 24 lines of growth, between which the shell is coarsely punctate; from 5–8 dots (when placed in a straight line) between the lines in the central part of the shell; these punctures are reduced to a single row on the edge. Length ·30; breadth ·23; thickness ·15 inch.

It differs from *E. Mexicana* Claus (Grube's figure) from Zimapan, Mexico, in the umbones being much more prominent; in

the prominent angle of the dorsal posterior edge, while there are half as many lines of growth. From *E. Dunkeri* Baird, also from Zimapan, it differs in the less numerous lines of growth; in the smaller, less tumid umbones, and the more marked angle of the posterior part of the dorsal edge. The punctures between the lines of growth are much more numerous in *Dunkeri*. Six specimens. Waco, Texas, April, G. W. Belfrage.

Estheria Morsei, n. sp.—Shell intermediate in form between *E. Caldwelli* Baird, from Lake Winnepeg and *E. Dunkeri* Baird, from Zimapan, Mexico; shell much swollen, oblong oval, of a pale horn color; umbones large, prominent, larger than in *E. Caldwelli*, and much less oblique and situated nearer the anterior end of the shell. Dorsal margin shorter than in *E. Caldwelli*, and in front of the umbones, instead of being straight and suddenly curved downward, is regularly rounded as in *E. Dunkeri*. Behind the umbones the shell is narrower than either in *Caldwelli* or *Dunkeri*; the dorsal edge sloping rapidly downward, without the well marked angle of *Caldwelli*, or the continuous, full curve of *Dunkeri*. Coarse punctures between the ribs, rather coarser than in *Caldwelli*, there being on an average 5–10 between the ribs in the center of the valve. Length ·50; breadth ·33; thickness ·24 inch. Six specimens from Dubuque, Iowa, collected by Rev. A. B. Kendig. Dedicated to Prof. E. S. Morse, who has indicated to me that the species was undescribed.

Lymnetis gracilicornis, n. sp.—This interesting form may at once be known from *L. Gouldii* Baird, recently found by Mr. E. Burgess in Cambridge, Mass., by the long slender 2d antennæ which have about 20 joints, and are much longer than in that species. The keel on the front of the head does not reach to the front edge, while in *Gouldii* it does. Shell of the same form but much larger than in *Gouldii*. Length of shell ·17, breadth ·16 inch.

Peabody Academy of Science, Salem, Mass., May 20, 1871.

Art. XV.—*On a New Difference Engine*; by Geo. B. Grant.

The great labor and expense involved in the construction of reliable astronomical and nautical tables by mental computation, as well as the impossibility of getting them entirely correct, suggested to Charles Babbage the idea that this work might be done almost entirely by machinery, and the machine he invented for that purpose has become famous, as one of the most complicated and costly pieces of mechanism ever contrived. The English government appropriated eighty-five

thousand dollars for its construction, on the strong recommendation of a committee of the Royal Society, containing some of the most eminent men of the time, but after years of study and labor had been spent on it, the appropriations were stopped on account of the indefinite expense. Though never completed as a working machine, it proved the feasibility of the scheme.

Babbage's idea was carried out more successfully by Edward Scheutz, and the two machines constructed on his plan are the only ones ever built for this purpose. One of these was bought for the Dudley Observatory at Albany, but has been but little used. The other was built by the British government in 1862, and has since been extensively used in the calculation of life insurance tables.*

The idea of contriving a machine for calculating tables first occurred to myself while laboriously computing a table for excavation and embankment. Having never heard of either Babbage's or Scheutz's engines, I imagined it an easy matter, but gave it up in disgust after some study. Last year I heard of Babbage's engine, became interested again, and designed a machine that might possibly have worked, but I could convince nobody that it would do so, and gave it up again. About four months ago, my teacher in the Mining School, Prof. Wolcott Gibbs, asked after the design, encouraged me in my work, and the result is the design for the difference engine, which it is the purpose of this article to describe.

Though I have built no large machine, the efficiency of the design for its purpose may be considered as having been proved, as through the liberality of the superintendent of the Coast Survey, Prof. Benjamin Peirce, I have been able to build a model of small capacity, which has worked to satisfaction.

I am indebted to Mr. John N. Bachelder of Cambridge, as well as to Professors Eustis, Winlock and Whitney, of Harvard College, for encouragement and help given. Mr. Bachelder had charge of the Scheutz engine when it first came to this country, and is one of the few who have had practical experience with any machine of this class.

A short explanation of the method of differences may not be wasted on many of my readers.

If the first term of any table be subtracted from the second, the second from the third, and so on, a new table will be formed, called the first order of differences. In the same way

* Accounts of Babbage's engine may be found in the Edinburg Review, July, 1834, in Taylor's Scientific Memoirs, v. 3, and in the inventor's work, "Passages from the Life of a Philosopher;" short articles on the same in Tomlinson's Cyc. of the Arts and Sciences; Harper's Mag., 1865; Manufacturer and Builder, 1870; Timb's Stories of Inventors, &c. Scheutz's engine is described in "The Swedish Calculating Machine," by Charles Babbage, in "The Manufacturer and Builder," Aug., 1870, and in detail in the British patent specifications, Oct. 17, 1854, No. 2216.

cond order can be formed from the first, a third from the nd, and ultimately an order of differences will be reached, ch is constant or nearly so. For example, take a table of cubes of the natural numbers, and forming the several rs of difference, it is found that the third order is invaria- six.

Table.	1st order.	2nd order.	3rd order.
1	7	12	6
8	19	18	6
27	37	24	
64	61		
125			

is plain that with nothing but the first terms 1, 7, 12 and ie table might be constructed to any extent by simple addi- . A difference engine is nothing but a machine to operate method, using several orders of differences, and a large iber of decimal places.

ı logarithmic, trigonometrical, and in fact in the greater iber of tables, there is no constant order, but one can be ıd that is so nearly so, that the error of considering it ıtly so will not creep into a given number of decimal places, any required number of terms have been calculated. A ı start must then be taken, and the table completed by a iber of such operations.

his engine, like both the others, consists of a calculating a printing part. In the printing part, the calculated results stamped into a sheet of lead, wax or other plastic substance, ı which a stereotype plate is taken for printing the table, avoiding constant error in copying the numbers and set- them up in type from manuscript. No description of this is given, as it contains nothing new of importance.

he calculating part consists of the main wheels, A, on which irst terms are set up, the additions made, and from which the ulated results are taken by the printing part; the drivers which make the additions, and the carrying apparatus C.

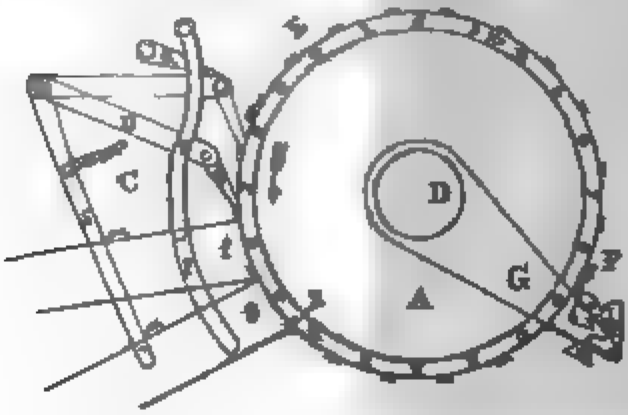
he main wheels are about one-third of an inch thick, and inches in diameter, all turning on the same axis D, in the e direction independently of each other, the axis being onary.

hey are arranged in sets of two, three or more, according ıe first, second or higher order is designed to be constant. re are as many of these sets as there are decimal places in largest number to be used. Each wheel is furnished on edge with twenty teeth, and on the other with two cams, ıd a', which project a little farther from the wheel than the ı. The spaces between the teeth are stamped with the ten ıerals, zero to nine, twice in succession.

The first set represents the units or lowest decimal place, the next set represents the next higher decimal place, and so on. The first wheel in each set represents the corresponding decimal place of the tabular number, the second wheel, that of the first order, and the last wheel is the constant order, and is furnished only with a cam, the teeth being omitted. It can be fastened at any figure, as it never requires to be changed after once being set. By this arrangement each wheel is separated by but the sixteenth of an inch from the wheels of the same place in the next higher and next lower orders.

The point E is chosen as the point at which to read all numbers, and it is evident that any number may be shown on any order by turning the wheels till the right numbers appear at E. The cams are so arranged with regard to the numbers, that one of them shall be at the point F when the wheel reads zero. Now as the wheel is turned, as every number passes E, the cam will be moved one space further from F, so that at any time the wheel could be read as well by observing the number of spaces the cam is distant from F, as by reading the figure at E.

The drivers B are attached to the carriage G, one driver opposite each wheel except the constant ones. They consist of a catch *b* and hook *c*. The catch is pressed toward the wheel, and the hook pressed on the catch by the same spring *d*. The carriage is driven by a crank over ten spaces on the wheels, and back again, making one oscillation to every turn of the crank. As the carriage leaves the rod *e*, the catch drops between the teeth of the wheel and carries it along. The catch projects over its wheel far enough to strike the cam on the next wheel when it gets to it, and be lifted out of the teeth by it, having added to its wheel the number of spaces that the cam is distant from F. As it is raised up, the hook catches in the nick *h*, and prevents it falling back on the wheel, so that it moves the rest of the stroke and back without moving the wheel. As the carriage comes back, the projection on the hook strikes the rod *e* and the hook is lifted out of the catch, letting it onto the wheel again.



It is necessary that while one wheel is being added to, the next wheel should not move. For this purpose the first stroke adds the first, third and odd orders to the numbers on the table, second, fourth and even orders, the odd orders being held firm by a clamp not shown. Meanwhile the rod *e* has been moved, so

that the drivers belonging to the even orders are not released as the carriage comes back, but those belonging to the odd orders, so that at the next stroke the even orders are added to the odd ones, and the number on the table-wheels printed; every two strokes of the carriage giving a new term of the table.

On each wheel between the teeth and cams are two grooves. The two slips *f* and *g* rest in these grooves, being held there by light springs. The pin *k* is so arranged that, when the wheel reads nine, it will be under the first slip *f*, holding it up; and as it passes from nine to zero it drops the slip *f*, raises and drops the slip *g*. To each wheel there is an arm H, to which the catch *m* is attached, the catch resting on the teeth of the wheel. This arm would be drawn back by a spring, but is held by two catches *p* and *q*. If the catch *p* is drawn, the arm will be held by *q* only, and if *q* is then drawn it will spring back, the catch falling over the next tooth. The slip *f* of each wheel is connected with the catch *p* of the wheel of the same order in the next decimal place higher, and the slip *g* with *q*. Each arm is connected by the lever *s* with its own slip *g*, so that it will draw it out when it springs back. As each nine on the wheel A comes to the point E, the slip *f* is pushed out, and the catch *p* to the next place B drawn; and as the zero comes to E, the slip *g* is pushed out, the catch *q* drawn, and the arm over B is sprung, drawing with it the catch *q* of the next place higher, C, but not releasing the arm at C, as it is still held by *p*. *p* will, however, be drawn, if B stands on nine, and both arms sprung, as it should be, for if the arm over B is released it indicates that one is to be added to it, and if it is already nine the addition of that one will make it necessary to carry one to C also. If C is nine, one must be carried to D, and so on; one must be carried to the first wheel which is not nine.

This is all done during the addition, after which and during the return of the carriage, the cam K brings all the arms back that are up, adding one to each wheel whose arm is up.

The entire printing part, as well as some details of framing, gearing, etc., are omitted from the accompanying sketch, which is meant merely as an outline drawing showing the principal parts only.

The size of a completed machine would vary with the capacity. An engine of the same capacity as that of Scheutz, would be three feet long, twelve inches high, and eight inches wide. The cost is estimated at from two to three thousand dollars.

Cambridge, June 5, 1871.

ART. XVI.—*A New Form of Galvanometer;* by JOHN TROWBRIDGE, Assistant Professor of Physics, Harvard College.

IN the tangent galvanometer the plane of the coil standing perpendicularly to the plane in which the needle moves, the needle is deflected by the action of the current passing through the coil upon the current circulating in the magnet; the magnet being considered a solenoid according to Ampère's theory. The tangent of the deflection measures the intensity of the current. The defects of the tangent galvanometer are well known. The poles of the needle in being repelled are removed from the field of the current and consequently with currents of great intensity the tangents are not closely proportional to the strength of the currents; the delicacy varying as the differential of $I = \tan \vartheta$, or $\frac{dI}{d\vartheta} = \sec^2 \vartheta$. When the ratio of the length of the needle to the diameter of the coil is a very small fraction, the tangents, however, are closely proportional to the corresponding intensities.

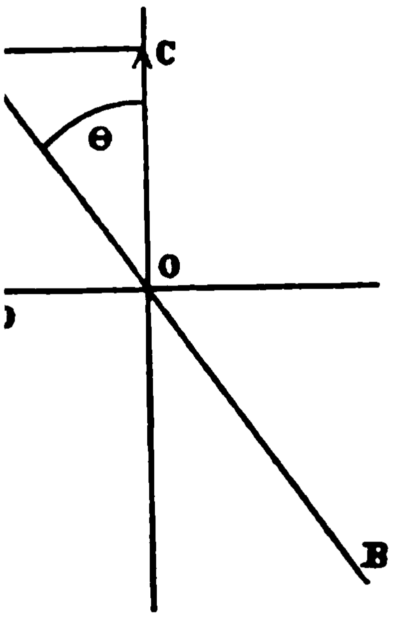
In Gaugain's galvanometer where the plane of the current is placed at a short distance from the axis of the needle, the intensities are directly proportional to the tangents of the deflections.

A mathematical investigation of the effects of electric currents on the magnetic needle, the plane of the current having different obliquities with regard to the horizontal plane in which the needle moves, led me to devise the following form of galvanometer:

A magnetic needle is placed at the centre of a circular current, the plane of the current at first being horizontal. In this position the needle is unaffected by the current, and is acted upon merely by the earth's magnetism. We now turn the plane of the current about a horizontal axis passing through the center of the needle as in the figure; A B representing the

of the coil in its new position, inclined at an angle of ϑ to the horizon.

ʼill be readily seen that if A O represents the intensity of rrent passing through the coil, O C will be the component that will deflect the needle; but O C= A O cos ϑ = I cos ϑ. The intensities will therefore be proportional to the cosines of the inclination of the plane of the current, measuring the angle from the vertical O C.



The instrument with which I experimented had the following dimensions: The diameter of the circle around which the current passed was twelve inches, and the length of the needle 1·4 inches; it was provided with long aluminum rs. The inclinations of the plane of the current were rom a vertical scale perpendicular to both the plane of rrent and to the plane in which the needle moved.

manner of experimenting was as follows: The resistf the battery—one Daniell's cell—having been determined are, and also the resistance of the circuit, the instrument rst used as a tangent galvanometer with the plane of the t vertical.

istances from one up to ten ohms were introduced into cuit, and the deflections noted; then with a constant re- e the angle was noted through which it was necessary to he plane of the current until the same deflection of the was obtained as in the cases where the instrument was s a tangent galvanometer with varying resistances.

following table gives the results obtained:

es	Angles of Deflection.	Ratio of Tangents.	Error.	Angles of Inclination.	Ratio of Cosines.	Error.
	18° 30′ / 75° 52′	·090	·014	85° 30′ / 0°	·078	·002
	32° 15′ / 75° 52′	·158	·016	82° / 0°	·139	·003
	41° / 75° 52′	·226	·026	78° 45′ / 0°	·195	·005
	54° 35′ / 75° 52′	·354	·021	70° / 0°	·342	·009
	15° / 32°	·428	·028	65° / 0°	·422	·022
	14° 30′ / 25° 30′	·542	·013	57° / 0°	·544	·015
	18° 30′ / 25° 30′	·701	·009	47° 45′ / 0°	·672	·020
	21° 30′ / 25° 30′	·825	·015	38° 15′ / 0°	·785	·025

It will be noticed that with large deflections the ratio of the cosines is nearer the ratio of the intensities than the ratio of the tangents. With smaller deflections, however, the ratio of the tangents is nearer that of the intensities than the ratio of the cosines. In the expression $I\cos\vartheta = CO = \tan\vartheta'$,

$$\text{or}\quad I = \frac{CO}{\cos\vartheta} = \frac{\tan\vartheta'}{\cos\vartheta},$$ if we differentiate I with respect to ϑ we obtain

$$\frac{dI}{d\vartheta} = \frac{\cos\vartheta\dfrac{d.\tan\vartheta'}{d\vartheta} + \sin\vartheta\tan\vartheta'}{\cos^2\vartheta}$$

It will be seen that the delicacy varies inversely as the cosine of the inclination decreases, or in other words, as the angle of the plane of the current with the vertical increases; the vertical component of the intensity increases while the horizontal component decreases. This vertical component thus renders the needle less sensitive to the horizontal component and dips it. By diminishing the length of the needle, and providing it with long pointers, and also increasing the diameter of the circle around which the current passes, the effect of the vertical component can be lessened.

With large deflections, therefore, this instrument appears to give closer results than the tangent galvanometer; and therefore supplies a deficiency in the latter instrument. By the cosine galvanometer many determinations of the intensity of the same current can be made by forming a table of the values of the cosines of different angles of inclinations in terms of the deflections of the needle, which currents, with a known resistance interposed produce. In the tangent galvanometer but one determination can be made.

Irrespective of the accuracy of this method, the instrument can be viewed as supplying a break in the literature of the subject. We have now in addition to the tangent galvanometer and the sine galvanometer, a cosine galvanometer.

My thanks are due to Prof. Cooke, of Harvard College, for the generous use of his apparatus for electrical measurements.

ART. XVII.—*Notice of some new Fossil Mammals and Birds, from the Tertiary Formation of the West;* by O. C. MARSH.

IN addition to the species of extinct Mammals described in the last number of this Journal, page 35, the Yale party, during their investigations in the Rocky Mountain region, discovered several others of interest, which are here briefly characterized. The remains of a number of fossil Birds were also found, and a

inary notice of the more important specimens is included present article.

Arctomys vetus, sp. nov.

.ains of Rodents are very rare in the Green river Tertiary although not uncommon in the more recent strata, east Rocky Mountains. A small species of the genus *Arc-* represented by a nearly perfect lower jaw, and other .s, was discovered during our explorations on the Loup iver. This species was only about one-third the size of odern *Arctomys monax* Gm., and may at once be distind from that rodent by the lower incisors, which have anterior surface a shallow median groove. The molar f the lower jaw have essentially the same composition e of the larger species.

Measurements.

. of lower jaw from condyle to base of incisor,	17·75	lines.
-posterior extent of four lower molars,........	6·5	"
of lower jaw below first molar,...............	4·5	"

specimens on which the species is based, were found by W. Wadsworth and the writer, in the Pliocene beds, on up Fork, in northern Nebraska.

Geomys bisulcatus, sp. nov.

ther extinct Rodent, about the same size as the prespecies, is indicated by several fragments of jaws and found in the same Pliocene Tertiary beds. The incisors lower jaw in this species have the anterior face broad t, with the external angle acute. They extend backward the entire molar series. The latter has a very similar sition to the molars of the recent *Geomys bursarius* Shaw, e two species may eventually prove to be nearly allied. pper incisors, likewise, are similar. On their anterior ere is a deep, rounded groove, with its lowest part just the median line. Near the inner angle, also, of each , there is a second, very fine, sharp groove. The external ngle is rounded, and the lateral face but slightly convex. emaxillary suture forms externally an obtuse angle, with ex forward, near the posterior face of the incisor. In .ws, the incisors are deeper than wide.

Measurements.

erse diameter of upper incisor, ...	1·6	lines.
-posterior extent, ...	2·	"
of skull at premaxillary suture,................	6·	"
. of lower incisor on arc of curve,..............	15·	"
rse diameter at apex, ...	1·5	"
of lower jaw below first molar,.................	5·6	"
-posterior extent of first three lower molars,.....	3·5	"

The only known specimens representing this species were found by the writer in the Pliocene strata, near Camp Thomas, on the Loup Fork river.

Sciuravus nitidus, gen. et sp. nov.

A very small extinct rodent of much interest is indicated by a portion of a left upper jaw, enclosing the last three molars, which was one of the treasures secured by the Yale party last autumn in the Tertiary beds of the Green River basin. The teeth preserved have apparently a near resemblance to those of the *Sciuridæ*, and hence the present fossil may be referred provisionally to that group. The genus is apparently distinct from any known, and will be more completely defined in the full description. The upper molars are composed essentially of two pairs of tubercles, with a minute intermediate cone on the outer edge. There is a strong basal ridge in front, and the inner margin is bifid. The species was about the size of the common brown rat, *Mus decumanus*.

Measurements.

Length of part of upper jaw, enclosing the three posterior molars,	3·4	lines.
Antero-posterior extent of antepenultimate upper molar,	1·	"
Transverse extent of same,	1·	"

This unique specimen was discovered by the writer at Grizzly Buttes, near Fort Bridger, Wyoming.

Sciuravus undans, sp. nov.

The present species was somewhat larger than the preceding, but probably a near ally. A single specimen only can now with certainty be referred to it, and a discussion of its exact affinities must be reserved for another occasion. The fossil in question is part of a right lower jaw containing the incisors and first three molars, all in excellent preservation. The incisor extends below the entire molar series. Its anterior surface is smooth, and somewhat convex, and the inner face, where the two teeth meet, is marked by a succession of delicate wave-like impressions. The tubercles of the molars are more prominent than in those of the last species.

Measurements.

Length of portion of lower jaw, containing first three molars,	3·5	lines.
Transverse diameter of third lower molar,	1·	"
Transverse diameter of lower incisor,	·6	"

This specimen was found by the writer at the same geological horizon, and near the same locality that afforded the species last described.

Triacodon fallax, gen. et sp. nov.

mall extinct mammal of much interest, is indicated by a lar tooth, and possibly by some additional remains, col- in the lower Tertiary beds of Wyoming. The tooth :s to be the last premolar of the right lower jaw, but so widely from the corresponding premolar in any known), as to render the nature of the animal to which it ;ed more or less uncertain. The crown is triangular at ise, the outer and longest side being somewhat convex, ıe other two nearly flat. The upper surface is composed ee triangular tubercles, one at each angle, the anterior much the highest, and the inner one the smallest. This ar tooth resembles slightly the corresponding premolar in ɔf the Insectivores, and is likewise similar in some respects ·se of certain Marsupials, but further remains will doubt- : necessary to determine its true zoological position. The t species was probably about two thirds the size of the American opossum.

Measurements.

›-posterior diameter of lower premolar,	2·25	lines.
ʳerse diameter of same,	1·95	"
t of anterior tubercle,	2·8	"
t of posterior tubercle,	1·6	"
t of inner tubercle,	1·75	"

the specimens supposed to pertain to this species were by J. M. Russell and the writer, at Grizzly Buttes, near se of the Uintah Mountains.

Canis montanus, sp. nov.

: presence of a large Carnivore in the fossil fauna of the River Tertiary basin, which could with comparative ıty be predicated upon the discovery there of so many :t pachyderms, was clearly established by our party; .gh the evidence at present rests on remains more or less ɜntary. Those already known consist of a last upper lar tooth in good preservation, a Canine, wanting most of ·own, and a number of the larger bones of a skeleton, all ɜntly of the same species, but pertaining to three indi- .s, differing somewhat in size. These various remains te an animal considerably larger than the recent Gray (*Canis occidentalis*), and one probably belonging to the family. The last upper premolar in the present extinct s is robust, has a short compressed crown. The principal s conical, with sub-acute edges, the anterior being about the length of the posterior. Behind the main cusp there .rge triangular tubercle, with its apex exterior to the fore

and aft axis of the crown. In the canine tooth, the base of the crown forms a broader oval than in most of the recent *Canidæ*.

Measurements.

Antero-posterior diameter of last upper premolar,	9· lines.
Greatest transverse diameter of same,	4·25 "
Height of main cusp,	6· "
Height of posterior tubercle,	3·75 "
Antero-posterior diameter of canine at base of crown,	7· "
Transverse diameter of same,	5· "

The above specimens were found by H. B. Sargent and the writer, at Grizzly Buttes, Western Wyoming.

Vulpavus palustris, gen. et sp. nov.

A second, much smaller carnivore is indicated by several upper molar teeth, and other fragmentary remains, found during our explorations in the same Tertiary deposits that yielded the preceding species. The specimens belonged to several individuals, all considerably smaller than a fox, and apparently having some affinities with that animal, although generically distinct. One of the best preserved of the teeth is a second, right, upper molar, which has a similar composition to the corresponding tooth of the common Red fox (*Vulpes fulvus* Desm.), but differs in the outline of the crown, which has the posterior side the longest, thus indicating a relative greater expansion at this part of the skull. The first upper molar, also, has a proportionally less fore and aft extent than the same tooth in the fox.

Measurements.

Length of portion of jaw containing last three upper molars,	10·5 lines.
Antero-posterior diameter of second upper molar,	2·35 "
Transverse diameter of same,	4· "

The specimens now representing this species were discovered by Dr. J. V. A. Carter, and the writer, near Fort Bridger, Wyoming.

Amphicyon angustidens, sp. nov.

Another extinct carnivore, about as large as the preceding species, and perhaps related to the same group, is represented by the anterior portion of a right lower jaw, containing the last three premolars, and the canine. The ramus is slender, but rather deep. The premolar teeth are low, and unusually compressed. All have a distinct tubercle in front of the main cusp, and the third and fourth have the posterior edge trifid. The present specimen agrees essentially in size with the corresponding jaw of *Amphicyon gracilis* Leidy, but the last premolar is less elevated, more compressed, and has the middle tubercle on the posterior edge much less developed than in that species.

Measurements.

Length of part of lower jaw containing four premolars,	9·5	lines.
Depth of jaw below last premolar,	5·	"
Width of jaw below last premolar,	2·1	"
Antero-posterior diameter of last lower premolar,	3·	"
Transverse diameter of same,	1·25	"
Height of crown,	1·8	"

This species was found by the writer, in the Miocene Shale, at Scott's Bluff, on the North Platte river, Nebraska.

Fossil Remains of Birds.

Since the beginning of the last year, when the first fossil Birds from this country were described by the writer,* but two additional species have been announced: an extinct Turkey, *Meleagris altus* Marsh (*M. superbus* Cope), from the Post-Tertiary of New Jersey,† and a Gannet, *Sula loxostyla* Cope, from the Miocene of North Carolina.‡ A special search was made by the Yale party last season for Bird remains, and a number of specimens were discovered, most of which were not sufficiently well preserved to admit of accurate determination. The few described below, although imperfect, are quite characteristic, and form an acceptable addition to the rich Tertiary fauna of the West, which has so long been deemed wanting in remains of this class.

Aquila Dananus, sp. nov.

An extinct species of Eagle, nearly as large as the modern Golden Eagle (*Aquila Canadensis* Cass.), is indicated by the distal portion of a left tibia, discovered during our explorations in the Pliocene beds of the Loup Fork river. The specimen shows, at its lower extremity, the peculiar fore and aft flattening, and the oblique, tapering supra-tendinal bridge over a deep canal, so characteristic of the recent birds of prey belonging to this genus. From the tibia of the Golden Eagle, evidently a nearly related species, the present fossil may readily be distinguished, aside from its inferior size, by the less concave inferior and posterior trochlear surfaces, and by the more prominent and well defined tubercle at the center of the ento-condyloid surface.

Measurements.

Width of condyles in front,	8·	lines.
Antero-posterior diameter of inner condyle,	5·25	"
Antero-posterior diameter between condyles,	3·3	"
Transverse extent of outlet of canal below bridge,	2·	"

* This Journal, vol. xlix, p. 205, 1870.

† Proceedings Philadelphia Acad. Nat. Sciences, 1870, p. 11, and American Naturalist, vol. iv, p. 317.

‡ Synopsis of Extinct Batrachia, &c., p. 236.

This unique specimen was discovered in July last by Mr. A. H. Ewing, in a Pliocene bluff on the Loup Fork river. The species is named in honor of Professor James D. Dana.

Meleagris antiquus, sp. nov.

A large Gallinaceous Bird, approaching in size the wild Turkey, and probably belonging to the same group, was a cotemporary of the *Oreodon* and its associates, during the formation of the Miocene lake deposits east of the Rocky Mountains. The species is at present represented only by a few fragments of the skeleton, but among these is a distal end of a right humerus, with the characteristic portions all preserved. The specimen agrees in its main features with the humerus of *Meleagris gallopavo* Linn., the most noticeable points of difference being the absence in the fossil species of the broad longitudinal ridge on the inner surface of the distal end, opposite the radial condyle; and the abrupt termination of the ulnar condyle at its outer, superior border.

Measurements.

Greatest diameter of humerus at distal end,	12·	lines.
Transverse diameter of ulnar condyle,	3·4	"
Vertical diameter of same,	4·	"
Transverse diameter of radical condyle,	4·25	"

The specimens on which this species is based were discovered by Mr. G. B. Grinnell, of the Yale party, in the Miocene clay deposits, of Northern Colorado.

Bubo leptosteus, sp. nov.

Several imperfect specimens of bird bones were found in the early Tertiary beds of the Green river basin, only one of which, however, the distal half of a left tibia, is sufficiently characteristic to suggest the near affinities of this species to which it pertained. This specimen shows that the tibia, when entire, was a slender, nearly straight bone, much compressed in an antero-posterior direction at its distal end, and having similar proportions to the same bone in the *Strigidæ*, or Owl family. The near resemblance is rendered especially striking by the entire absence of the osseous supra-tendinal bridge, which is wanting in this group, and in a few other birds with which the present species is apparently less nearly allied. The fossil under consideration would indicate a species about two-thirds the size of the Great Horned Owl (*Bubo Virginianus* Bon.), the tibia of which it resembles in nearly all essential particulars. There is, however, no trace of a fibular ridge on the outer surface of the distal end, as in that species, or on the portion of the shaft preserved; which would seem to imply a generic difference between the two forms, and additional material will doubtless prove such to be the case.

Measurements.

Length of portion of tibia preserved,	15·	lines.
Width of condyles in front,	6·5	"
Transverse anterior diameter of inner condyle,	2·5	"
Transverse anterior diameter of outer condyle,	1·8	"

This specimen, the only known representative of the species, was found by the writer last autumn at Grizzly Buttes, near Fort Bridger, Wyoming.

Yale College, New Haven, June 12th, 1871.

ART. XVIII.—*Notes on the distribution of the Vegetation of Santo Domingo*; by W. M. GABB.

MUCH has been said and written on the singular phenomenon, exhibited on a grand scale in our western prairies as well as in South America and elsewhere, of large treeless areas, strongly circumscribed, and covered with grass. Innumerable theories have been advanced to account for the absence of forest growths over these tracts, and the entire absence of even isolated trees has been a cause of unlimited speculation. This is the more strange since it is found that when trees are artificially planted, they flourish, and the occupation of these tracts in the Mississippi region is covering them with vigorous groves.

Upwards of two years of residence in "the garden of the Antilles" has given the writer an opportunity of studying the matter here, as well as of making some general observations on the distribution of the vegetation of Santo Domingo.

To most persons who have never been in the tropics, the term presents a vision of tangled jungles, endless climbing vines, and waving palms. Few think of broad swelling prairies and smiling meadows as compatible with a landscape below the Cancer. But both exist in charming variety, not only in the favorite home of Columbus, but over much of our little known neighbor, the continent of South America.

On the Island of Santo Domingo, the grass and tree regions are sharply defined, and correspond in the main with certain geological features. First, the whole mountain region is covered with tree-growth to at least a little distance beyond its base. Second, the valley of the Cibao, the great valley occupying a fourth of the Republic of St. Domingo proper, and running east and west on the north side of the Island, is in the main a tree region, with scattered savannas, as will be described farther on. Third, the south side of the island, outside of the mountain tracts, is nearly equally divided between forest and prairie.

Observation proves that in each and every case the relation between the soil and its growth is constant. The mountains are composed of easily decomposable rocks, which produce a rich soil. This supports dycotyledonous trees of an infinitude of species, with a dense undergrowth in which climbing vines, some with trunks three and four inches thick, are the most marked feature. But there are tracts, more especially on the northern flanks of the range, where the soil is a red gravel. Here, without reference to altitude, (except that it does not extend into the plains) the forest growth is coniferous—a tall slender species of long leaved pine, and invariably, under the pines is a scattered growth of grass. The only other marked effect of altitude on the vegetation in these mountains is the almost invariable existence, above a height of say 2500 to 3000 feet, of dense thickets of a tall slender fern, which renders the higher peaks almost absolutely inaccessible.

The Tertiary rocks, which constitute the Cibao valley and northern range of mountains, never carry pine. The eastern half of the valley is covered in part with a very deep black mould, always bearing dense forests, and with a gravelly or clayey soil always covered with grass. This valley lies directly in the course of the trade winds; its eastern end, at Samaná bay, being open like a funnel to draw in the moisture-laden breezes from the Atlantic. As the current draws down the valley, confined by the hills on both sides, it deposits its vapors so liberally in the Vega, or eastern end, that by the time it reaches the middle of the valley, it is perceptibly dryer. The inevitable result is a striking change in the vegetation. The soil, which in the mountains would be pine lands, or in the Vega would make of this one continuous savanna of fifty miles long, here bears a straggling growth of low Acacias and Cacti. Among the latter, a Cereus of twenty to thirty feet high and an arborescent Opuntia often twenty feet high, are the most marked. In the more fertile soil, both on the lower hills and in the valley, lignum vitæ (Guayacan) abounds, and logwood (Campeachy) frequents the moist bottom. Throughout the Cactus and Acacia tracts, grass grows sparsely.

The mountains approach the coast, west of Santo Domingo city, leaving small plains only, until near the great bay of Ocoa. East of this broad spur is a strip of plains nearly thirty miles wide extending to the eastern end of the island. The underlying geology, and consequently the surface soil, is here divided into two well marked groups. In the Post-pliocene era, the coast line followed the present mountain base, and the mouth of the Jaina river was twenty-five or thirty miles farther northwest than at present. This stream runs through a region of hard rocks; and its débris, now spread over the country like a fan,

s consequently a coarse gravel, gradually changing into a clay or sand, as the distance from the old mouth and coast line increases. Still further, where shore influences fade out, the same strata are continued, but instead of appearing as a loose gravel, they become calcareous, and, in the then deep sea, change to beds of coral limestone.

The underlying gravels sands and clays are always covered with grass while the calcareous rocks make, as invariably, a tree region. In consequence of this, the whole coast, for a width of about ten miles near St. Domingo city, and gradually becoming wider eastward, is a great forest covering about two thirds of the plain. Mahogany grows only on calcareous soils, and this is thus the great mahogany-producing region of the Republic. It also abounds in logwood.

The same condition of the winds, though in a less degree than in the north, exists on the south side. Saybo is a rainy region, Azua is dry. About thirty miles west of Sto. Domingo, the region of cactus begins, the acacias straggling ten miles farther east. With the above mentioned species of Cereus and Opuntia, a small Echinocactus is most common here. Here again reappears the lignum-vitæ with considerable quantities of fustic.

I have not had an opportunity of examining the region northwest of Azua, which is infested by roving bands of Haytian marauders, but from the meager information I have been able to obtain, I am led to infer that there, there is no marked variation from the general rule of the rest of the country.

Throughout all the savannas, whether on the north or south side of the Island, almost every depression, and every watercourse is marked by its clump or line of trees; the spots being equally characterized by a richer soil, brought there by the surface drainage of rain waters. This, in connection with the other facts stated above, points to the inevitable conclusion, that the richer soils produce forest, and the poorer, grass growths. Independent of the tendency in the trees to monopolize the richer soil and kill out the grass by their shade, there comes in to the aid of the humble growths an important agency, which prevents or retards the spread of the forests which would otherwise inevitably overrun all the grass land in the end. This agency is fire. The edges of the tree tracts are as sharply defined as if attended by a careful gardener. The annual fires so scorch and burn up the smaller bushes, the advance guards of the larger trees, that it is doubtful, in the process of encroachment, which has the advantage.

ART. XIX.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XV.—*Descriptions of Starfishes and Ophiurians from the Atlantic coasts of America and Africa;* by A. E. VERRILL.

THE genus, *Goniaster*, as restricted by Dr. J. E. Gray in 1840, includes several beautiful species of starfishes, which are still very rare and imperfectly known. Dr. Gray named three species, without giving descriptions sufficient for their identification, all of which were from unknown localities, and two of them were apparently known to him only from the rude figures of Linck and Seba. I am unable to refer the two following species to either of the species named by him.

Goniaster Americanus, sp. nov.

Form pentagonal with deeply and regularly concave edges. Radii as 1 : 1·8. Rays considerably less than half the diameter of the disk, triangular, tapering, with slightly incurved sides. The disk is somewhat convex, especially at center, and covered with rather large, polygonal plates, which are separated by lines of pores, and on the rays by small groups and circular clusters of granules. The plates, unless supporting a spine, are closely covered with small polygonal granules, with a well-marked larger series around the edge; those that bear spines have the marginal granules and two or more series of the smaller ones around the base of the spine. In the center of the disk is a single spine, around this are five larger ones, each of which is the first in a row of 4 to 8 spines extending along the middle of the ray, but usually interrupted by plates destitute of spines; bordering the middle of the central row, on each side, there is a row of 5 or 6 similar spines; outside of these a row of 3 or 4 smaller spines; and beyond these usually 1 or 2 spines; thus the middle region of each ray has a broad-oval group of spines, broadest toward the center of the disk.

The groups of spines are separated by depressed interradial zones, destitute of spines; in each of these there is a rounded plate, outside of and alternating with the spines of the central pentagon; beyond these there are, in four of the zones, a pair of rather large plates, in contact by their straight inner margins; in the fifth zone a large convex madreporic plate takes the place of these. The upper marginal plates are 14 to each interradial margin, about as long as broad, very convex, the three median ones largest, and rising into two blunt tubercles or spines, which are united at base; most of the others, except the penultimate ones, bear a single, conical, blunt tubercle, decreasing in size toward the end of the ray. Lower mar-

nal plates 22 to each margin, the median ones smooth, con-
x, nearly twice as high as wide, the lateral edges straight and
contact; those toward the ends of the rays become rounded,
out as broad as high, and the last four or five plates bear sin-
e, stout, blunt tubercles. The marginal plates are surrounded
r either one or two rows of granules. The plates of the
wer surface are closely covered with polygonal, round-topped
anules, smallest toward the edges of the plates; a few plates
ar the mouth bear one or two stout central tubercles; others
ar the ambulacral grooves, and especially toward the margin,
ve a smooth central area, perforated by one or more small
res and bearing as many peculiar pedicellariæ, which consist
two, slender, spatulate, or spoon-shaped blades, often curved
terally, and usually seen widely open, when they are received
to grooves or pits in the plate, exactly fitted to their forms.
milar pedicellariæ of smaller size exist at the base of many
the dorsal spines.

The interambulacral plates bear, at their inner edges, a row
about 4, prismatic, nearly equal, blunt, spines; and outside of
ese an irregular crowded group of 4 to 6, stouter, but scarcely
nger, blunt spines, the outer ones shorter; these form three
four irregular rows.

Radius of disk 1·45 inches; of rays 2·60; length of largest
rsal spines ·30; diameter ·20 of an inch. Color of the dried
ecimen yellowish brown, when fresh bright red.

Off Charleston, S. C., from the mouth of a Black-fish,—Prof.
U. Shepard.

Goniaster Africanus, sp. nov.

Depressed, pentagonal, with shorter rays and less concave
lges than the preceding species. Radii as 1 : 1·6. Rays broad
iangular, obtuse, the last upper marginal plates larger than the
hers and more swollen. Plates of the upper surface smaller
d more numerous than in the preceding, and more coarsely
d irregularly granulated. Spines smaller, but much more
merous, the clusters scarcely separated and covering most of
e surface; the median row of the rays, with 10 to 12 spines;
e first laterals with about as many; the second laterals with
or 6; the third, with 3 to 5. Upper marginal plates 10 to
ch interradial margin, smooth, convex, the median ones nar-
west, higher than broad; the last one largest, rounded, very
nvex; none bear spines or tubercles. Lower marginal plates
3 to each margin, smooth, convex, destitute of tubercles, except
casionally a minute one on some of the last plates. Ventral
lates covered with very unequal rounded granules, those on
he central part much larger than the others, in the form of small
ound tubercles. No pedicellariæ observed. Interambulacral

spines arranged much as in the preceding, but more slender and less numerous, the outer ones forming two or three rows.

Radius of disk 1·06; of rays 1·70; length of longest spines ·17; diameter ·12 of an inch. Color of dried specimens light orange-red.

West Coast of Africa,—Capt. W. W. Hall. Received from the Peabody Academy of Science, Salem, Mass.

Amphipholis abdita, sp. nov.

Disk small; arms much elongated, about 12 times the diameter of the disk, of nearly uniform diameter throughout the greater part of their length.

Six mouth-papillæ in each angle of the mouth, and two to four additional small rounded papillæ, or tentacle scales, near the extreme outer angle. Two of the mouth-papillæ on each side are placed close together, at about the middle of the edge of the jaw; the outer of these, which is about twice as wide as the inner, is flat, scarcely longer than wide, with the end obtusely rounded or truncate; the inner one is scarcely wider than thick, oblong, rounded at the end; in one case these two papillæ are united together. The third mouth-papilla is stout and rounded, obtuse, larger and longer than either of the others, separated from them by a considerable interval, and brought close to the tooth at the end of the jaw, beyond which it projects inwardly and downwardly.

The mouth-shields are long-oval, narrowed outwardly, the outer part of the lateral edges being nearly straight, the outer end rounded, the inner end broadly rounded. Side mouth-shields triangular with the three edges concave, the inner ends not united, the surface finely granulated. The lower arm-plates are separated by the side plates; the two first are longer than broad, pentagonal, the inner end forming an obtuse angle, the outer edge straight; the two next are about as wide as long, squarish, with the corners rounded or truncate; the following ones are broader than long, somewhat octagonal, the outer and inner edges longest and nearly straight; beyond the middle of the arm they are again pentagonal, with an inner angle. On the first five joints there is usually only a single pair of tentacle-scales, which are small and rounded; on the succeeding joints there are generally two pairs, one of them being considerably smaller than the other.

Arm-spines three, on all the joints except the first, which has but two; they are thickened at base, gradually tapering, blunt at tip, subequal, the lower ones a little curved downward: length about equal to width of lower arm-plates. The upper arm-plates are transversely subelliptical, with the outer edge well rounded, the inner edge slightly prominent or angular in

ıe middle, and a little concave to either side, so that the lateral ortions are somewhat narrowed; the plates generally touch ıch other, but scarcely overlap, unless close to the base of the rms. The upper surface of the disk has been destroyed in ıe only specimens seen. Diameter of disk about ·38 of an ıch; length of longest arms (broken at the ends) 4 inches.

Color in alcohol uniform light yellowish, when living tinged rith greenish.

Off Thimble Islands and Savin Rock, near New Haven, in 3 › 6 fathoms, muddy bottom, living buried in the mud with one rm thrust out of its burrow.

I have been aware of the existence of this species for several ears, having on several occasions dredged a single detached rm, but it was not until last autumn that I succeeded in obtainıg a specimen with the disk, and even in this the covering of ıe dorsal side was destroyed.

It is somewhat allied to *A. gracillima* (Stimpson), of S. Carona, and has similar habits. The latter has more slender arms, ›ur or five arm-spines, and different mouth parts.

Ophiophragmus Wurdemanni Lyman, Catalogue, p. 132.

This species is common at Fort Macon, N. C., living in the ınd at low water, where it was obtained by Dr. A. S. Packard nd Dr. Elliott Coues. It varies considerably in color, some ›ecimens being yellow, with few dark markings; in others ıe dark brown bands predominate. The disk is brown above, ghter below.

The arms are very long and slender. One of the largest has ıe arms 6 inches long, and the disk ·4 in diameter. The ›aling of the disk is variable, and generally coarser than in [r. Lyman's type specimens. The radial shields are usually in ›ntact. The under arm-plates, near the base of the arms, are narginate and slightly bilobed.

.RT. XX.—*Notice of the Meteoric Stone of Searsmont, Maine;* by CHARLES UPHAM SHEPARD, Mass. Prof. of Natural History in Amherst College.

FOR the particulars concerning the fall of the Searsmont ıeteorite I am indebted to Mr. E. B. Sheldon, postmaster of the ljoining village of Searsport, and to the Republican Journal f Belfast, Maine, of Thursday, May 25th.

Mr. Edward Burgess of Searsmont furnished the short notice ontained in the newspaper. He states that the fall took place n the southern part of the town, at about 8 o'clock on Sunday norning, the 21st instant. "There was first heard an explo-

sion, like the report of a heavy gun, followed by a rushing sound resembling the escape of steam from a boiler. The sound seemed to come from the south, and to move northwardly. The stone fell in the field of Mr. Bean, the flying earth being seen by Mrs. Buck, who lives near. The hole that it made was soon found and the stone dug out. It was quite hot and so much broken as to be removed only in pieces. The outside shows plainly the effect of melting heat. It struck with such force as to penetrate the hard soil to a depth of two feet."

The following is the substance of Mr. Sheldon's letter. Mr. Luce, who dug the stone, tells me he reached the spot about fifteen minutes after it struck, when he found the fragments still quite warm. The largest piece weighed two pounds. All together, the pieces amounted to twelve pounds. They emitted the odor given off by stones violently rubbed together. The hole produced by the descent was vertical in its direction, and two feet in depth. The character of the soil was a hard, coarse gravel; and the shattering of the stone was produced by its finally meeting three large pebbles, (each about four pounds in weight) in the course of its descent. "Mrs. Buck, who saw it fall, or rather saw the scattering of the soil on its entering the ground, was reading at the time in the house, distant about thirty rods from the spot. The time was 15 minutes past eight. She first noticed a report about as loud as that of a heavy gun, or of a rock-blast, such as they hear from a lime-quarry situated about a quarter of a mile distant. This was followed by a rumbling noise, as of a number of carriages passing over a bridge. She rose and looked out from a back door, then re-crossed the room to the front door, where, after the lapse of about ten seconds, she saw the dirt in motion from the contact of the stone with the earth. She thought it must have been nearly two minutes from the first report, until the stone struck the ground. No one went to the place for 20 or 25 minutes. The report was heard in Warren, twelve miles to the southwest; likewise a hissing sound as of escaping steam. No report or sound was heard in Searsmont village, three miles to the northeast."

Through the kind assistance of Mr. Sheldon, I am in possession of the largest remaining mass of this meteorite. Its weight is two pounds. Fully one-half of its surface is coated with the original crust. Its shape would seem to denote an oval, subconical figure in the original mass, with a flattish base, so as on the whole to have approached the shape of the famous Duralla (India) stone, (Feb. 18, 1815), now preserved in the British Museum.* The coated part of my specimen, which

* Of which I possess an excellent model, presented me while that stone was still in the collection of the East India House.

rresponds to a portion of what constituted the base of the ipposed cone, differs in shape and color from the two oval ıdulating sides, which make therewith angles of between 60° ıd 70°. The broadest of these sides (above three inches in ngth) where it meets the base, forms a blunt rounded edge, obscurely striated vertically to the intersection, and shows a ight thickening about the edge, as if matter had been swept ver from above and accumulated somewhat on the under side. othing is plainer than the distinction in character between ıe upper sides and the base. The crust of the latter is perctly black, more thoroughly fused, with a blebby, somewhat assy, reticulated surface, whose lines are without any order; hile the upper surfaces are more even and almost destitute of ıe blebby and veined appearance. Feeble striæ are visible ɜar the basal side, all of which are perpendicular to the same. he color of the upper surfaces is brownish black; and these e wholly without luster.

The thickness of the crust is more than double that found in ıy stone belonging to my collection,—amounting at least to ıe-sixteenth of an inch. The stone is rather below the average respect to frangibility. The color is bluish-white, and remarkɔly uniform, except from feeble stains of peroxide of iron, ıd from silvery white, metallic points, produced by the meteoric ɔn. More than half the stone is in the form of rounded ains, mostly with roughened or drusy surfaces, and of a size rely exceeding mustard seeds. Between these, and often ırtially coating them, is a fine grained subcrystalline white, grayish-white mineral, which I take to be chladnite. It is ther loosely coherent, and without visible crystalline structure. ıdeed, as seen by the microscope, it is often porous, reminding ıe of the siliceous skeletons obtained in fluxing certain silites in blowpipe experiments. This white mineral may form quarter or more of the stone.

The rounded globules are bluish-gray, rarely with a faint nge of yellow, vitreous in luster and translucent, with two nperfect oblique cleavages. On the whole, they resemble the naltered grains of boltonite more than any of our terrestrial ıinerals; and differ only in their greater tendency to assume ıe globular figure.

Minute points of bright meteoric iron are very thickly scatred through the mass. A few grains of troilite, the largest f the size of small kernels of Indian corn (maize), likewise resent themselves; together with a single blackish mass of milar dimensions, which on being touched with the point of knife was found to be soft, and left a bright metallic streak. is probably a plumbaginous aggregate. Sp. gr. of the aggreate = 3·626.

In general character, it approaches most nearly to the stones of Quenggouk (Pegu, India) that fell Dec. 27, 1857, differing from them in having more of the fine whitish gangue, and in possessing a thicker and more blebby crust. It also presents points of resemblance to the Aussun (France) meteorite of Dec. 9, 1858: but the latter has a much thinner crust, a darker colored general basis or gangue, much larger globules, and at the same time, it is a firmer stone.

There is even an internal similarity between the Searsmont meteorite and that of Duralla. They approach each other in the thickness and general character of the crust: but the whole of the latter is darker, and the regularity in the shape of its globules is less marked.

Should I succeed in recovering a portion of the now widely scattered fragments of this interesting stone, I shall enter upon a more detailed examination of its character.

Letter to the Editors from Dr. B. A. Gould, *Director of the Cordoba Observatory, dated Cordoba, April* 26, 1871.

[Concluded from page 80.]

The magnificence of the Milky Way in this vicinity is indescribable, surpassing the Pleiades or the Præsepe in richness, and exhibiting numerous huge clusters, the sight of which through the Tolles telescope evokes exclamations of astonishment and delight from every beholder, young or old, whether with or without astronomical information. Keen as was my desire for a photographic equipment before leaving home, it has been a hundred-fold increased since I began the survey of this most gorgeous of all the regions of the sky. Even yet I have not abandoned some hope that the friends of astronomy at home may be disposed to provide means for some permanent photographic record of these magnificent groups and splendid double stars. The transparency of the atmosphere would greatly reduce the needful time of exposure, and it gives peculiar opportunities for the success of the photographic method in other respects.

The news from the Eclipse-observers—so long and anxiously expected—is just beginning to arrive; our mail facilities having been sadly interfered with by the quarantine, established at Rosario, which has for more than two months placed an absolute interdiction upon all personal communication with Buenos Aires. From such accounts of the eclipse as have yet come to hand, it would seem that the results tend to confirm the doctrine that the corona is of a composite character, although this idea met with such opposition prior to the eclipse: but that my other observation, to which I attribute a good deal of importance, viz:—the change of outline in the more conspicuous and external portion of the phenomenon during the period of totality was neither verified nor the reverse, since the unfavorable atmospheric influences appear to have cut off this part of the exhibition at those few stations from which accounts have been received here. You may imagine with what eager interest we are awaiting the arrival of more detailed accounts from Europe or the United States.

You have unquestionably heard of the fearful pestilence which has been desolating the capital of this republic. The yellow fever, which broke out there at the close of January, has made such ravages that all commerce has

spended, banks and public offices are closed, and not less than ⅘ths of ulation have fled to the suburbs. The gates of the only practicable the interior of the country have been closed by the absolute interdic- travel which the municipal authorities of Rosario have succeeded in ıg, notwithstanding the fever appears to have been purely local, and no authentic account of the disease being communicated in a single the distance of five miles from the center of the city. A few fatal cases ccurred where the patient left the city after contracting the infection, great majority in such cases have recovered. Within the city limits nos Aires, the mortality has been terrific, reaching at one time a daily of 500 in a population reduced, by the flight of all who could escape, mber probably not much, if at all, exceeding 50,000.—The official re- ive a total of more than 15,000 deaths from yellow fever since the of February up to which time the fatal cases were restricted to a single nd seldom amounted to more than eight or ten a day. At first, too, ter classes escaped, but ultimately all classes were attacked indis- tely, and in all parts of the city. The disease is at present on the uite rapidly, and the telegraph officials are returning to their posts, so are in daily receipt of more encouraging accounts.

ng the minor evils of this fearful epidemic have been the financial ir- ities from which not only all government institutions, but likewise all rcial and social relations, have suffered. Even the Observatory has not l its share of these, although all public officers have done their best in ılf, and have shown a most gratifying and encouraging interest. The ı and authorities of Cordoba, too, have shown themselves desirous of us on all occasions and in every way, and the Observatory has suffered lly less than other public institutions in this exceptional condition of

ientific faculty is now organizing in this ancient university; and the ors of Chemistry, Botany, and Mineralogy have arrived from Germany e already engaged in their respective researches. The flora of this seems to be a characteristic one, but to contain a peculiarly small num- pecies. The professor of botany is making extensive collections, from our own museums will doubtless profit in good time.

re this reaches you, I trust that not only will the observatory have been ted by the erection of the portion which left the United States in Jan- d is probably at this very moment in the waters of the River La Plata, g the reopening of the port of Buenos Aires, but also that our regular ork will have fairly begun. Still we have become inured to delays, and rous prosecution of the Uranometry leaves no time to be consumed in ations.

u know of any good man who has a few thousand dollars which he is d to contribute to the advancement of Astronomy, please tell him that re few if any ways in which they could be so effectively bestowed, curing photographs of the Southern sky at the present time. I have e here the object glass with which Mr. Rutherfurd took his magnificent aphs of the Moon, the Pleiades, the Præsepe and the cluster in Per- d am only in need of a mounting for the telescope, chemical equip- nd a trained photographer, all of which a little money would enable us re without delay.—With these appliances, more astronomical material sort, to which the photographic method is specially adapted, could be d in two years, than without it in twenty. And this material, once , can be elaborated at any subsequent time and the work repeated by nber of independent investigators.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Spectrum of Uranus.*—The spectrum of Uranus was first observed by Secchi in 1869. He noticed a complete absorption of the yellow rays, while there were two large black bands, one in the green and the other in the blue. The band in the blue was less refrangible than F; that in the green was near E. Mr. Huggins has observed the spectrum of this planet with a 15-inch refractor by Messrs. Grubb & Son, and has determined the existence and position of six strong absorption bands. The positions of these bands were measured by means of the micrometer and by comparison with the spectra of terrestrial substances. The strongest of the lines has a wave length of about 0·000544^{mm}. The others corresponded respectively to wave lengths of about 0·000572^{mm}, 0·000595^{mm}, 0·000618^{mm}, 0·000486^{mm} and 0·000634^{mm}. The band at 0·000572^{mm} is nearly as broad but not as dark as that at 0·000544^{mm}. The band 0·000486^{mm} corresponds to F of the solar spectrum. The author found that the absorption bands of Uranus could not be ascribed to the presence of carbonic acid, and also that there is no strong line in the spectrum of the planet which corresponds to the strongest of the air lines, the double line of nitrogen, although the two planetary bands 0·000595^{mm} and 0·000618^{mm} very nearly coincided with bright lines of air.—*Proceedings of the Royal Society, and Nature, for June 1st*, 1871.

W. G.

2. *On the application of the Spectroscope to the measurement and comparison of the intensity of colored light, and to the quantitative determination of Coloring Matters.*—Vierordt has succeeded in applying the spectroscope to quantitative determinations of considerable interest and importance. To determine the relative intensity of the light of different portions of the spectrum, the author employs a spectroscope provided with the ordinary scale telescope. The scale itself is however removed, and a slit arrangement similar to that of the collimator substituted. This slit is illuminated by a constant source of light, which serves as the standard. The intensity of this light may be varied either by varying the width of the slit, by changing its distance from the source of light, or by the employment of smoke-tinted glasses as absorbing media. The image of the slit being reflected from the surface of emergence of the prism appears superficial upon the spectrum, and when the intensity of the white light from the constant source is sufficiently intense, the spectral color at a given point will disappear. If now the intensity of this light is diminished gradually, a point will be arrived at for which the parts of the field of view illuminated by the pure spectral colors can no longer be distinguished from the corresponding part illuminated at the same time by the spectral colors, and by the faint white light. It is to be borne in mind that if the dark lines in the spec-

are vertical, the white image of the slit occupies only a por-
of the central line of the spectrum, so that the pure spectral
s admit of direct comparison with those which are diluted
superficial white light. The principle of measurement de-
s therefore upon the capacity of the eye to distinguish dif-
ces of intensity of light of different colors. For the descrip-
of the apparatus employed and the details of the method, we
refer to the original paper. The author describes, however,
part of the apparatus, which we shall here notice as a valua-
ddition to the spectroscope when used for other purposes.
consists of a moveable plate carrying an adjustable slit,
h is introduced into the eye-piece of the observing telescope,
at the plane of the slit coincides with that of the image. The
nay be made to traverse the whole field of view, by means of
ew; in this manner the whole spectrum may be excluded
view, with the exception of a given narrow portion. This
igement enables the observer to examine a limited part of the
rum for a long time without fatigue to the eye, and is of spe-
ise in examining faint positive* spectral lines.

another paper the author points out a method of applying
pectroscope to the quantitative determination of coloring mat-
The moveable plate which forms one half of the slit of the
mator is divided into two portions, each of which can be
ed parallel to itself by a micrometer screw with divided head.
n the two slits are of exactly equal breadth, the upper and
r halves of the spectrum will have the same intensity. If
of the slits, for example the upper, has a colored glass or
r absorbing medium placed in front of it, the spectrum will
ivided into two halves of unequal intensity. If now the other
e narrowed gradually by means of the screw, the intensity
ie light will gradually diminish until it becomes exactly equal
he two halves of the spectrum at a given part or region of
. The equalization of the light in the two halves of the spec-
is quickly produced, and in this manner the ratio between the
tity of light transmitted through the colored plate and the
nal intensity of the light is easily expressed in percentages.
represents the degree of concentration of a colored solution,
coefficient of extinction and A the coefficient of absorption
e dissolved active substance, we have $C=AE$. Hence the
ee of concentration of a solution may be found by simply
uring its coefficient of extinction, provided that the coeffi-
of absorption of the dissolved substance has been determined
for all. The author promises hereafter a work on the appli-
n of the spectroscope to quantitative chemical analysis.—*Die
endung des Spectral-Apparates für Messung und Vergleich-
ler Stärke des farbigen Lichtes, Tübingen*, 1871; *Berichte
Deutschen Chem. Gesellschaft, 4ter Jahrgang*, No. 6, p. 327.

W. G.

* avoid circumlocution, it seems desirable to employ the terms positive and
ve, to denote respectively bright or dark lines or bands.—W. G.

3. *On the heat of neutralization of organic and inorganic bases soluble in water.*—J. THOMSEN in Copenhagen, has published the principal results of a recent investigation of the quantities of heat evolved in the neutralization of different bases of the same acid. These researches have led to the remarkable result that the so-called hydrates of the oxides of K, Na, L, Tl, Ba, Se, Ca and Mg evolve on saturation with sulphuric acid the same quantity of heat, the neutralization being in all cases that of one molecule of sulphuric acid. The quantity of heat evolved amounts to 31134 as a mean, the single values differing almost ½ of 1 per cent from this mean. Sulphuric acid evolves with other inorganic bases a less quantity of heat. Thus the heat of neutralization of PbO is 18750^c; that of Ag_2O 14040^c. The author infers from this result that the chemical character of the process of neutralization is different in different cases. Thus the first named eight bases do not evolve the same quantities of heat with one molecule of other acids. Thallium with chlorhydric and sulphydric acids behaves like silver, so that the numbers are nearly the same for the two metals. A solution of ammonia in water differs remarkably from the inorganic alkaline hydrates. Thus it gives with sulphuric acid only 28150^c, or 11 per cent less than the alkaline hydrates. On the other hand, tetra-methyl-ammonium-hydrate gives with one molecule of sulphuric acid 31010^c, or almost exactly the same number as the eight inorganic bases. Ethylamin gives nearly the same number as ammonia, namely, 28350^c. Triethylstibin-oxide, a divalent base, gave with sulphuric acid hardly 10 per cent of the heat of the alkaline and earthy bases, whence the author infers that it is a base of a wholly different character. From the above mentioned results, he considers it probable that an aqueous solution of ammonia does not contain a hydrate of ammonium, and that it is only an ammonium-base proper which is analogous to an alkaline hydrate. In conclusion, the author promises an investigation of the thermic relations of the organic bases. —*Berichte der Deutschen Chem. Gesellschaft*, 4*ter Jahrgang*, p. 308. W. G.

II. GEOLOGY AND NATURAL HISTORY.

1. *Currents of the Oceans.*—Mr. JAMES CROLL, in the Philosophical Magazine for 1870, volume xxxix, sustains the view that the currents of the oceans, including the Gulf Stream, are due to the action of the trade winds. Dr. W. B. Carpenter, in consideration of the results obtained by the deep ocean soundings has presented positive evidence that the ocean is stirred by its currents to its very bottom (this Journal, vol. xlix, p. 410, 1870), and claims, we think rightly, that the superficial action of the trades is not sufficient cause for the movement. An elaborate memoir by Dr. Carpenter "on the Gibraltar Current, the Gulf Stream and the General Oceanic Circulation," has been published during the current year by the Royal Geographical Society, from which we cite his conclusions, after stating the general principles on which he bases them.

A vertical circulation is maintained in the Strait of Gibraltar by the *excess of evaporation* in the Mediterranean over the amount of fresh water returned into its basin, which at the same time *lowers its level* and *increases its density ;* so that the *surface-inflow* of *salt* water which restores its level (exceeding by the weight of salt contained in it the weight of fresh water which has passed off by evaporation) disturbs the equilibrium and produces a *deep outflow*, which in its turn lowers the level.—The same may be assumed to be the case in the Strait of Babelmandeb.

A vertical circulation is maintained in the Baltic Sound by an *excess in the influx of fresh water* into the Baltic; which at the same time *raises its level* and *diminishes its density*, so as to produce a *surface outflow*, leaving the Baltic column the lighter of the two, so that a *deep inflow* must take place to restore the equilibrium.—The same may be assumed to be the case in the Bosphorus and Dardanelles.

A vertical circulation must, on the same principles, be maintained between polar and equatorial waters by the difference of their temperatures; the level of polar water being reduced, and its density increased, by the surface-*cold* to which it is subjected, while a downward motion is also imparted to each stratum successively exposed to it; and the level of equatorial water being raised, and its density diminished, by the surface-*heat* to which it is exposed. (The first of these agencies is by far the more effective, since it extends to the *whole depth* of the water, while the second effects, in any considerable degree, only the *superficial stratum*.) Thus a movement will be imparted to the upper stratum of oceanic water from the equator toward the poles, while a movement will be imparted to the deeper stratum from the Poles toward the equator.

Of such a *vertical circulation* in the general body of oceanic water we have evidence, on the one hand, in the *northerly* movement of the upper stratum, *of several hundred fathoms' depth*, which carries the temperature of a warmer region into the Arctic circle; while, conversely, there is now a large body of evidence as to the *general prevalence*, over the deep-sea bottom, of *a temperature not many degrees above the freezing-point of fresh water*, which cannot be accounted for in any other way than by an underflow of polar water toward the equator. Further, under particular circumstances, a yet greater degree of cold is brought by glacial currents into the Temperate zone: thus giving distinct indication of a general movement of deep water from the poles toward the equator.

Lastly, it follows, if the foregoing doctrine be correct, that the general *vertical* oceanic circulation is the great agent in moderating the extreme cold of the Arctic basin; the water which flows toward it being not so much propelled into it by the Gulf Stream, as drawn into it from an area of which the ordinary temperature is little, if at all, above the normal. On the other hand, the Gulf Stream forms part of a *horizontal* or *superficial* circulation in the

North Atlantic, of which the Trade Wind constitutes the *primum mobile:* a large part of its flow returns directly backward into the equatorial current, thus completing the *shorter* circulation; whilst the portion which passes northward ultimately returns in the *superficial polar currents* with which it interdigitates—one of these currents being sufficiently powerful to maintain a distinct course back to the exit of the Gulf Stream, where its deeper portion not improbably re-enters the Gulf of Mexico as a reverse under-current through the Narrows.

The view which Dr. Carpenter advocates, that the movement of the ocean affects the whole body of water to its very bottom, is recognized by the writer in his Report on Crustacea of the Wilkes Exploring Expedition, (4to, 1618 pp., 1852, this Journ., II, xvi, 1853), and the general system in this circulation is there pointed out,—this system according with the views previously held by the distinguished meteorologist, W. C. Redfield. The conclusions are sustained by facts relating to the temperature of the ocean observed in the course of the cruise of the Exploring Expedition just mentioned, and others from various sources, presented on an isothermal chart prepared for illustrating the geographical distribution of marine life, and especially the Crustacea; and a brief statement of this system is given in his Manual of Geology, (1861). The facts from the deep ocean remove all remaining doubt with regard to the universality of the movement, and the oneness of the system. At the same time there does not appear to be any good reason for separating from the system the Gulf Stream, as done by Dr. Carpenter. Given the vertical circulation, and the north and south movement, advocated by him, and then the revolution of the globe will make it, as has been long recognized, a *westward* movement in the tropics and an *eastward* in the middle and higher temperate latitudes, such as is found in fact in all oceans. Then, secondly, whenever, in the flow of these waters, they approach the continents, where the depth diminishes, the rate of flow will be increased in proportion (approximately) to the decrease of depth; and hence comes the stream east not only of North America and there called the Gulf Stream, but of South America, and also those east of Asia and of Australia; and also that in the higher latitudes west of South America. The Gulf Stream and all these other streams, are parts of the general system, modified by proximity to the continents; the action of the trades is not in any case their origination, though it may well be their accelerator. Neither is an Indian ocean current the origin of the current in the South Atlantic up the west side of Africa, though contributing to it.

Dr. Carpenter also combats Mr. Croll's position, with regard to the "thermal work of the Gulf Stream." J. D. D.

2. *On the "Benches," or Valley Terraces, of British Columbia;* by MATT. B. BEGBIE, Chief Justice of British Columbia.—The following extracts from this paper are selected from the Proceedings of the Roy. Geogr. Soc. for Feb. 27, 1871.—It is perhaps scarcely possible for any person who has never seen Fraser River, or ob-

tained an accurate description of it, if any verbal description can be accurate, to form an idea of its banks.

The distance from Lytton to Lilloett is 43 to 45 miles, and this may seem a considerable extent of bench formation when compared with Glen Roy, which extends but 20 miles. But the bench formation in British Columbia extends the whole distance of Fraser River so soon as the delta is left, as far as I have traveled up it, i. e. full 400 miles, and then the benches are seen running on, miles ahead. Wherever the formation has a chance of showing itself from Hope upward, i. e. wherever it is not interrupted by precipices, or chasms, or denudations, there are benches more or less clear and regular. Up the Quesnelle River, and on Cottonwood, an affluent of Fraser River next above Quesnelle, and Lightning, affluent of Cottonwood, up to within 25 miles of the Bald Mountain, the backbone of the Cariboo range, I still found exactly similar benches. The formation extends all up Thompson River, far above Kamloops, along both forks, as far as I could see. There are several well defined terraces on the Okanagan; in particular on the "Rivière du Sable," halfway down the lake, mounds like truncated pyramids, or rather a pile of four or five truncated sections of pyramids. On the only portion of the Columbia River which I have traveled, viz: Fort Shepherd to Fort Colville, the formation is just as distinct and striking as on Fraser River, and I am informed and fully believe that it is quite uninterrupted down to Snake River, in lat. 46°. The largest benches, both in length and breadth, that I have seen are in the valley of the Upper Kootenay River, about long. 115° 30′ W. (Lilloett being 122° W.). At Rock Creek, and all along Kettle River, the trails run for miles and miles along just such benches, and so too all along the Similkameen River and the Nicola River, not only at its influx into the Thomson, where there are six or eight heaped one upon top of another, but all along its course to the Nicola Lake. In fact, it may be said that everywhere in the Colony on the east side of Fraser River, wherever there is a river of any size, and the hills or mountains are near, but not too near, you find yourself on one of these benches, more or less regularly formed, but even when externally irregular, bearing traces of original regularity.

The benches are to all appearance in their normal state, level in the direction of the neighboring stream. But I suspect that they follow its general inclination—it might be said, incline "conformably" with the stream, as a general rule. For instance, it is very common for ditches—which, of course, always have some fall, though their fall varies extremely from an inch in a mile to an inch or more in a yard—to be carried along a bench in the direction of the principal stream, very rarely against that direction, and only when the supply is taken from a side creek, when, of course, the ditch may be taken in any direction. This question could not be determined without levelling a good many benches carefully. I should not be disposed to place much reliance on a barometer for such minute differences of level, and any hypsometer I have seen would be useless. But as to the transverse inclination (i. e. in the

direction at right angles to that inquired of by Mr. Robinson), a great many benches, especially as they recede from the river, have a very decided inclination, i. e. they slope from the mountain toward the stream, and sometimes very rapidly, as if an upheaving force had burst through a slightly flexible stratum of drift, and raised it to the highest point just before it finally emerged. Nevertheless the benches sometimes slope the reverse way; so that I know two or three instances of benches where lakes are formed next to the mountain base, the bench presenting an appearance similar to the "lip" on rivers running through alluvial flats, but which appearance is, I think, due to quite a different cause from the "lip," viz: to a local depression having taken place after the formation of the bench.

Just before reaching Lilloett, the benches become exceedingly striking. Speaking from memory, I should say there were at least five or six different benches, apparently as level, green, and well defined as billiard tables, on the east bank, and a still greater number on the west bank, or Lilloett side, where they are intersected in a most picturesque way by the brilliant N'Koomptch, running through the magnificent gorge leading from Seton Lake, about three miles from the Fraser, the northern extremity of the Douglass trail already referred to.

There are, I should say, speaking from memory, at and in sight of Lilloett, at least 15 or 16 benches on both sides at various levels, some three or four on each side of Fraser River exactly corresponding in level: but many on either side of the river having no apparently exact counterpart on the other bank. Lilloett stands on a plateau, which I judge to be about 160 feet above high-water mark of Fraser River, varying, between March and June, from 30 to 40 feet vertical. I have never been on the highest bench in this neighborhood, which I should say is on the east side, and which I should judge to be 500 or 600 feet above the Fraser.

There are, I should think, on the fort side (west bank of the river) at least twelve or fifteen terraces immediately at Alexandria; and from their regularity and contiguity—being generally narrow, and differing only a few feet in height—present a very singular and striking appearance: like a gigantic flight of steps ascending the hillside gradually.

The above are the more important facts presented by Mr. Begbie. From them he draws the conclusion that the "benches" or terraces are due to a vast lake, or series of lakes, and that this drainage was connected with an elevation affecting "a large mass of the continent," raising, at different periods, "various ridges of hills and mountains, either together or separately," and resulting in protruding them through the wide spread lacustrine formation.

8. *Note on River Terraces;* by J. D. Dana.—The first observations on the terraces of Oregon and California will be found in the Geological Report of the Wilkes' Exploring Expedition, by the writer, published in 1849, and in this Journal, 2nd ser., vol. vii, in which places the terraces or benches are attributed chiefly to river action. They are shown to be part of a system of terraces that

covers a large part of North America, north of the Ohio, and existing on all streams, as far as examined, nearly to their heads in the mountains, as stated above to be the fact with those along some streams on the Pacific border. It is there remarked that if admitted to be lake terraces, the facts would prove that a large part of the continent had been covered with lakes in place of rivers, and just where rivers should have existed, which is a view not to be entertained.

The lower flats or flood grounds now existing along any stream follow it to its head, with interruptions depending on the width of the valley and nature of the enclosing deposits (whether hard rock or not); and thus such flats, while the sea has its present level, may exist on a single river at all heights, from a few feet above the sea level to the height approximately of its source, or through a range of level it may be of thousands of feet. Such flood grounds are approximately parallel to the adjacent bed of the stream, the variations depending largely on obstructions in the course of the stream and being such very nearly as actually exist between flood level and low-water level.

If now a part of the continent be raised 50 feet, the abrading or excavating force of the streams would be increased; the low-water channel would be accordingly deepened by abrasion, and a new flood ground or lower flat would also be produced with the old flood ground as a terrace or bench. The height of this terrace or bench would depend on the depth of the river excavation; and this on the nature of the bottom, etc.; thus with a single elevation of 50 feet, terraces may be made at all heights above the sea from 50 feet to 5000 or more, according to the height of the head-waters of the rivers. This fact is of the highest geological importance; very many errors as to evidences of changes of level have been made from a failure to consider it. Moreover, more terrace levels than one might be formed on this single sudden rise of the land wherever there were obstructions that were afterward successively removed. Such obstructions might in some parts of a stream make lakes, and cause true horizontal benches for an interval. Thus the terraces or benches along streams may be accounted for without recourse to lakes except those that would be incidental to such a system of river changes. They are evidences that the stream has excavated its bed to a lower level than that which it formerly had; and the proof as to change of level indicated is to be derived not from an isolated fact in any place, but from a general survey of all the facts throughout a great region—facts as to heights of terraces, as to excavating force of stream in its different parts, and as to possible obstructions that have put a limit to excavation or occasioned intervals of retardation.

4. *Glaciers.*—The Philosophical Magazine for June, (pp. 485–508) contains a translation of a valuable paper on Glaciers from Poggendorff's Annalen, by ALBERT HEIM of Zurich. The following paragraphs are from pages 495, 496.

M. Grad ascribes to the freezing of the infiltrated water in the capillary fissures, not only the enlargement, but also the "crystallographic orientation" of glacier-ice, discovered by Bertin, and afterwards confirmed and generalized by MM. Grad and Dupré. But he seems to me to form no accurate conception of how this is to be produced by the water freezing round the surface of the grains. It might be very difficult to do so. I am inclined rather to look upon the "crystallographic orientation" as a function of the pressure. The ice masses of the lower part of the glacier, in which it has been observed, are not the same which in the upper part did not exhibit the phenomenon; they are those which, during many years, have sustained the mighty pressure of the overlying layers of ice, now melted away. When we consider that, in a body the temperature of which is always near its melting-point, molecular derangements readily take place, and that there is no lack of shocks which go through the mass of ice (such as occurs, for example, in the crash whenever a crevasse opens or closes), the latter notion becomes still more probable. The phenomenon observed by MM. Bertin, Grad, and Dupré, that in lamellæ cut horizontally out of the lower part of the glacier colored rings with a black cross are seen when they are viewed in the polarizing microscope, does not necessarily indicate actual crystalline structure; amorphous glass can yield the same phenomenon through strains forced upon it by external pressure. It appears to me that the effect in the glass also would necessarily be permanent, if the violent pressure had operated for many years. Experiments on a small scale, for the purpose of producing by pressure the crystallographic orientation in pieces of ice, gave no result. This is not surprising; for I could not, as many a glacier does, operate with a pressure of 5 cwt. per square inch, or factors of similar magnitude. Already in the 27th volume of the Philosophical Magazine Sir John Herschel conjectured a parallel arrangement of the optic axes, but not on grounds corresponding with M. Grad's explanation.

I must not, however, omit to mention that, according to the calculations of an Englishman (Canon Moseley) in the Philosophical Magazine for May, 1869, the resistance of the ice to the shearing-forces of the glacier-motion would be too great for the ice to be broken by gravity alone and thus the glacier to move by its own weight. If I rightly understand the experiments of Tyndall and my own on the remoulding of plates of ice, the ice therein and in the glacier is not compelled to shear, but to break by the bending. The shearing, tangential displacements take place along the fissures previously produced by fracture (bending). The very peculiar mechanical conditions of the ice seem to me not to have been sufficiently considered in the calculation. One of these is its extraordinary brittleness even at 0° C.; the same pressure which a mass of ice will sustain in a state of rest for a long time without breaking, breaks it immediately if a shock is added. Another is the occurrence of crowds of minute air-bubbles, which must very

much diminish the compactness of the ice. In the lower part of a glacier, where air-bubbles are almost absent, we have the old, only half regelated secondary capillary fissures, along which fresh fracture is easier: while in this region the primary fissures are somewhat less numerous, the secondary (which are longer preserved) exhibit a peculiar abundance of plaits. So many factors, unmeasured in their effect and scarcely known in their mode of operation, are involved in the mechanics of glacier-motion, that the result of a calculation based on the little that is known cannot possibly induce me antecedently to reject the explanation by pressure, with which all the facts of which I have any knowledge, and all that I have seen, agree so perfectly. According to the explanation of glacier-motion given by Mr. Moseley (Phil. Mag., Jan. 1863 and Aug. 1869), the total motion must be, on the average, equal in amount in the upper, middle, and lower parts of the glacier, which is not the case. As in no part of the glacier, certainly not at the lower end, has any (even the least) upward motion ever been observed at certain times, the line which, as a base, remains relatively fixed must, when the temperature falls, lie at the upper end of the glacier; when the temperature rises, at the lowest point. That with rise of temperature the lower end would remain stationary, and drag after it the whole long glacier-tongue (which cannot descend by its own weight), without its being rent transversely into single independent fragments, I cannot conceive. The surface of the glacier undergoes more and greater variations of temperature near its margins than in the center—now from reflection of heat from the sides of the valley, then from their shade, but especially through the winds (which in the center arrive with their temperature already approximated to that of the glacier). The margins have in some measure a more continental, the center a more oceanic climate. Hence one would think that the edges of the glacier would move faster than, or at least as fast as the center, if variations of temperature effected the motion.

I have not the remotest intention to summarily reject Mr. Moseley's views; but I thought it admissible to state what at present appears to me opposed to them, in order to justify my continuing to hold Professor Tyndall's explanation. Perhaps Mr. Moseley will be able to remove these difficulties and, especially by measurements of the interior temperature of glaciers, give his views a better foundation.

5. *On Sigillaria, Calamites and Calamodendron.*—Dr. J. W. Dawson, in the Q. J. Geol. Soc. for May, 1871, discusses the nature of these fossil plants and presents many facts of his observation. The tissues of the Sigillariæ, and the character of the fruits (*Trigonocarpum* and *Cardiocarpum*) which very often accompany the trees, are regarded as proving that they are true Gymnosperms or are related to the Conifers and Cycads. But he further remarks that possibly the group may have included forms bridging over the interval between the higher Acrogens (the Calamites on one side and the Lepidodendron on the other) and

the Gymnosperms. The *Calamites*, according to Dr. Dawson, are true Equisetaceous plants, and the fossils exhibit the exterior surface of the stems. But other fossils marked externally like Calamites are casts of the pith or *internal axis*, and belong to the genus *Calamodendron*. The Calamodendra often have a considerable thickness of woody envelop about the apparently jointed internal axis, consisting of woody tissue in wedges separated by intervening tracts of cellular tissue (medullary rays according to Williamson); and they are therefore classed by Dr. Dawson with Gymnosperms.

Dr. Dawson makes the line from Sigillaria to Lepidodendron to include, in order, *Lepidophloios*, *Syringodendron*, *Clathraria*, *Favularia?*, *Rhytidolepis*; and the line from *Sigillaria* to *Equisetum* to include *Calamodendron Calamopitus* (of Williamson), *Bornia*, *Calamites*.

6. *Lepidodendra and Sigillariæ.*—In a paper read before the Royal Society, June 15, Prof. W. C. Williamson describes the structure of specimens of *Lepidodendra selaginoides*, and appears to make good the conclusion that it has an imperfect exogenous structure. He observes that it has a central medullary axis, which is closely surrounded by a second and narrower ring also of barred vessels, but of smaller size, and arranged in vertical radiating laminæ "which are separated by short vertical piles of cells believed to be medullary rays. In a transverse section the intersected mouths of the vessels form radiating lines," and the structure is pronounced an early type of an exogenous cylinder. From this cylinder alone the vascular bundles going to the leaves are given off.

He describes *Stigmaria* ("well-known," he says, "to be a root of Sigillaria,") as having "a cellular pith without any trace of a distinct outer zone of medullary vessels such as is universal amongst the *Lepidodendra*. The pith is immediately surrounded by a thick and well-developed ligneous cylinder, which contains two distinct sets of primary and secondary medullary rays." Other facts stated tend to show that these plants are of the Lepidodendroid type, and Prof. Williamson therefore includes the *Lepidodendroid* and *Sigillarian* plants in a common family, making them, along with the *Calamiteæ*, to constitute an *Exogenous* division of the vascular Cryptogams, while the *Ferns* belong to an *Endogenous* division, "the former uniting the Cryptogams with the Exogens, through the Cycadeæ and other Gymnosperms; and the latter linking them with the Endogens through the Palmaceæ.

7. *Helderberg Corals in New Hampshire.*—Prof. C. H. Hitchcock, State Geologist of New Hampshire, announces the discovery of Helderberg corals in Littleton, N. H. New Hampshire has been considered an Azoic State by some, as its rocks are mostly of a granitic character. Professors H. D. and W. B. Rogers supposed at one time they had found Silurian fossils in the White Mountain Notch, but afterward withdrew the opinion.

The limestone containing these corals has been traced for about three miles, and appears to be duplicated by a synclinal fold. It overlies the metamorphic Quebec group on one side, and probably the Coös group on the other. It appears to be overlaid by a clay slate carrying a few worm-trails.

The corals themselves are obscure. They have been submitted to the examination of E. Billings, F.G.S., of Montreal. He recognizes the *Favosites basaltica*, and a *Zaphrentis*. The rock appears to be identical with that cropping out upon lake Memphremagog and its supposed continuation into Vermont. The New Hampshire locality is fifty-five miles southeasterly from the Canadian. As the associated rocks are somewhat similar, it is likely that the two limestones are of the same age. Mr. Billings does not speak positively of the distinctive age of the Canadian limestone. It seems to range from the Lower to the Upper Helderberg. He compares it with the Gaspé limestone, which corresponds with the entire Helderberg series of New York. A fossil from Owl's Head, shown to Professor Hall by the writer several years since, was declared to be the peculiar *Atrypa reticularis* of the Upper Helderberg. With our present information it is only possible to say that Helderberg fossils have been found in New Hampshire. C. H. H.

8. *On Fossil Coal plants from the Altai;* by Dr. H. B. Geinitz. (From Cotta's "Der Altai," in course of publication).—The coal plants here noticed were brought by Dr. Cotta from the Museum of Barnaoul. They are mostly of described species already recognized there by Eichwald and others. The species remarked upon are *Equisitites Socolowski* Eichwald, *Anarthrocanna deliquescens* Göpp., *Cyatheites Miltoni* Artis, *Annularia longifolia* Brgt., *Cyclopteris orbicularis* Brgt., *Sphenopteris anthriscifolia* Göpp., *Lepidodendron Serlii* Brgt.; a *Pterophyllum* near *Pt. inflexum* Eichw. (on same specimen with *Annularia longifolia*); *Trigonocarpus acteonelloides* Gein., *Nœggerathia æqualis* Göpp., *N. palmæformis* Göpp.; *N. distans* Göpp.; *Araucarites Tchithatcheffianus* Göpp.—Geinitz mentions the fact of the occurrence of a Cycad, *Pterophyllum blechnoides* of Sandberger, in the Carboniferous beds of the Baden Schwarzwald, to show that the Siberian species is not a solitary case. The memoir is illustrated by three lithographic plates. Dr. Geinitz remarks in closing that the species are not Permian, and that they belong to the later Carboniferous.

9. *Preliminary Report on the Vertebrata discovered in the Port Kennedy Bone Cave;* by Prof. E. D. Cope, (Proc. Am. Phil. Soc., April 7, 1871).—This paper, mention of which is made in vol. i, on page 384, of this Journal, (May, 1871), contains descriptions of 5 species of Megalonyx, *M. loxodon*, *M. Wheatleyi*, *M. dissimilis* Leidy, *M. sphenodon*, *M. tortulus*, *Mylodon? Harlani*, *Sciurus calycinus* Cope, *Jaculus? Hudsonius* Zimm., *Hesperomys* ——?, *Arvicola speothen* Cope, *A. tetradelta* id., *A. didelta* id., *A. involuta* id., *A. sigmodus* id.; *A. hiatidens* id.; *Erethizon cloacinum*

id.; *Lepus sylvaticus* Bachm.; *Praotherium* (a genus near *Lepus*, Cope) *palatinum*; *Scalops* ——?; ? *Vespertilio* ——; *Mastodon Americanus*; *Tapirus Americanus*; *T. Haysii* Leidy; *Equus* ——?; *Bos* ——?; *Ursus pristinus* Leidy; *Felis* ——? In all there are 34 species, and 72 individuals. Of them, 11 are American tropical forms, 3 North American Arctic, 11 are common to both hemispheres; and 9 are of uncertain regional relations. Prof. Cope concludes with a discussion of the relation of the species to the earlier American fauna, the geographical and other changes of the Post-tertiary, and the origin of the cave.

10. *Winkworthite*; Prof. How.—Winkworthite is a borate occurring in nodules in the gypsum quarry at Winkworth, Hants Co., Nova Scotia. It forms nodules, as large as a walnut. A surface of fracture was flat, and was covered with glistening irregular facets, and scrapings showed under the microscope transparent oblique-angled plates. H. = 3, but of outside 2. In the closed tube yields water and becomes opaque. B.B. decrepitates and fuses easily to a clear bead, giving a bright green flame; in continued blowing, froths, the bead becomes opaque and the flame loses its green color. Analysis afforded Sulphuric acid 36·10, silica 3·31, boracic acid by loss 10·13, lime 31·66, water 18·80, which composition affords the atomic proportions 9$\dddot{S}$, $\ddot{Si}$, 3$\bar{B}$, 11$\dot{C}a$, 20$\bar{H}$.

Another nodule afforded $\dddot{S}$ 31·51. $\ddot{Si}$ 4·98, $\bar{B}$ by loss, 14·37, $\dot{C}a$ 31·14, $\bar{H}$ 18·00, whence the ratio, 8$\dddot{S}$, $\ddot{Si}$, 4$\bar{B}$, 11$\dot{C}a$, 20$\bar{H}$.

Ulexite has been found in Nova Scotia, in gypsum, at Clifton Quarry, Windsor; Brookville; Trecothick's Quarry; Three Mile Plains; Winkworth; Newport Station. *Cryptomorphite*, in Glauber salt in gypsum at Clinton Quarry. *Howlite*, in gypsum and anhydrite at Brookville, and in gypsnm at Winkworth, Newport Station, and Noel.—*Phil. Mag.*, April, 1871.

11. *Trinkerite.*—A fossil resin, described by Tschermak, containing over 4 p. c. of sulphur, from an Eocene coal bed, at Carpano in Istria. This sulphur-bearing resin has been observed also, by T. Niedzwiedski, at Gams, near Hieflau in Styria, imbedded in a dark colored rock of the Upper Cretaceous formation.—*Bulletin of the K. Akad. Wien. Nature*, No. 87.

12. *Arrangement for Cross fertilization of the flowers of Scrophularia nodosa.*—It is probable that the dichogamy of the flowers of *Scrophularia* has already been observed and published; but it was new to me until pointed out this season by my assistant, Dr. Farlow. The arrangement is thus: In the freshly opened blossom the upper part of the style is bent forward so as to bring the stigma now ready for pollen, just over the patent lower lip of the corolla: the anthers, not yet dehiscent, are out of sight toward the bottom of the corolla, the filaments being strongly recurved or doubled over. In the blossom a day or two older, the stigma has dried up, the style become flabby; and the filaments have straightened so as to bring the four anthers up to the gorge of the corolla at the base of the lower lip, just back of the now withering stigma; the transversely dehiscent anthers are now widely open. The

owers are visited by honey-bees, which barely insert their heads ito the gorge of the flowers; the chin or throat of the bee, coming into contact with the lower lip of the corolla, is necessarily usted with pollen from the older flowers; and this pollen, in ie passage from flower to flower, and plant to plant, is inevitbly applied to the stigma of the freshly opened flowers, which lone is in condition to receive it. The nectar sought by insects here secreted abundantly by the corolla, at its base on the posterior side, and to some extent by the disk which girts the base of he ovary; the posterior face of the scale which represents the nther of the fifth stamen is apparently glandular, but hardly if t all nectariferous. Bees plunge their proboscis to the bottom of he flower. A. G.

13. *Transmutation of Form in certain Protozoa.*—Mr. METCALFE OHNSON has a paper on this subject, in the number for May, No. 29), of the Monthly Microscopical Journal, (London), presentng views similar in some respects to those of Mr. Hilgard, (pages 0 and 88, of this volume). The following passages from the article resent the general conclusion of the author.

In the 'Monthly Microscopical Journal' for April, 1870, I ave ventured to remark that "Monas and its congeners become t once important as agents in removing dead cells, and in their lace supplying us with *green* verdure which is springing up round us on every side." Everyone must have observed that niversal greenness which, after the lapse of a few weeks, spreads iore or less over every weather-exposed surface, large or small. ir Humphrey Davy, writing forty years ago, says, "A polished urface of a building or a statue is no sooner rough than the seeds f lichens and mosses which are constantly floating in the atiosphere make it a place of repose, grow and increase." If we xamine a few of the green growths upon these surfaces differing rom one another in their surroundings, or "choses extérieures," ach as moisture, light, temperature, &c., we shall find one comosed of a green dust, to which the name of *Chlorococcus* has een applied; another, a green scum upon the surface of a liquid, 'hich has received the name of *Euglena;* a third, forming atches of dark green slime upon old walls, and called *Oscilltoria;* a fourth, *Lyngbya;* a fifth, *Vaucheria;* a sixth, *Schidmema*, and so on. A more detailed examination of these sepaately-named products, and a study of their life-history, leads to he opinion that they are all (more or less) stages of development f some one common source, which it is the object of the present emarks to identify as the monad, or pin point, source of life, 'hich has been pointed out by Dr. Bastian and others as the earest form in which we recognize living matter.

In order to commence this investigation I will append a few bservations I have made on various forms of *Paramœcium*, and shall endeavor to show that it constantly transforms to *Vorticella*, nd thence passes to *Callidina elegans*, thus tracing one of the hases of growth by development from the simple form of *Monas* o some of the more complicated animalculæ or Entomostraca. I

shall hope in a future communication not only to trace the *Paramœcium* from the monad, but also to show that the "choses extérieures" being altered the monad may become a *Chlorococcus*, an *Oscillatoria*, a *Lyngbya*, a moss, a lichen, an *Amœba*, or a *Mucedo*.

14. *Embryological Studies on Diplax, Perithemis, and the Thysanurous genus Isostoma;* by A. S. PACKARD, Jr. Memoirs of the Peabody Academy of Science, Volume I, Number 2. Salem, Mass., March, 1871.—This memoir contains quite full and interesting descriptions of the development of the embryos of *Diplax* and *Isostoma*, with a few observations on *Perithemis*. "An interesting point in the embryology of *Isostoma* is the homology of the spring. Though its earliest development was not observed, it is evidently homologous with the third pair of blades comprising the unjointed ovipositor of the higher insects, and seems to be homologous with the legs and cephalic appendages." Dr. Packard also suggests that the three pairs of processes ordinarily forming the ovipositor of insects are homologous with the abdominal legs of myriapods and the spinnerets of spiders. He also concludes that the eyes and ocelli of insects do not represent limbs and that they arise on segments bearing other appendages, and, therefore, the head of insects may be considered as composed of but four segments. This memoir is illustrated by two plates and several wood-cuts. V.

15. *Seaside Studies in Natural History;* by ELIZABETH C. AGASSIZ and ALEXANDER AGASSIZ. Second edition, 1871. (James R. Osgood & Co., Boston).—This is one of the few books on Natural History which combine scientific accuracy with a popular treatment of the subject. It is, moreover, the only popular work in which many of the most interesting marine animals of our shores are described and figured. It is, therefore, gratifying to see that the work has been so well appreciated as to require a second edition. In this edition but few changes have been introduced. These are chiefly in the chapter on the distribution of marine life. A list of the wood-cuts and an explanation of the abbreviations of authors' names have been added. V.

16. *Report on the Brachiopoda obtained by the U. S. Coast Survey Expedition, in charge of L. F. De Pourtales, with a Revision of the Craniidæ and Discinidæ;* by W. H. DALL.—Bulletin of the Museum of Comparative Zoology, Vol. iii, No. 1, Cambridge, Mass.—In this paper all the species dredged by Mr. Pourtales are fully described, and the synonymy of these and other species and genera is well worked out. The anatomy of several of the species is described at considerable length. Two lithographic plates, chiefly anatomical, illustrate this paper. V.

17. *Arrangement of the Families of Mollusks;* by THEODORE GILL. Smithsonian Miscellaneous Collections, February, 1871.—In view of the wide diversity of opinion among zoölogists concerning the classification of Mollusca, it is not to be expected that any scheme that can be proposed at present will be generally adopted. Yet we are constantly approximating to a true natural classification of these animals, thanks to the numerous anatomical investigations that have recently been undertaken. The author of the

nt work fully acknowledges the provisional character of the gement which he has adopted, and anticipates many changes fter. In reality, some improvements made within the past would doubtless have been adopted, had not the work been pe some six months before its actual publication. It is, never-ss, the best index to the classification of the Mollusca that een published hitherto. It gives in a very convenient form rangement in accordance with the views of many of the most le malacologists. It is probable that in numerous cases too families have been admitted, or divisions of minor value been allowed family rank. This appears to be especially for the Nudibranchs, where the classification of Dr. Gray een followed. But such imperfections are of comparatively importance in view of the uses for which this "arrangement" tended. It is accompanied by a useful list of authors and an betical index to the names of the classes, orders, and fam- Mr. Gill admits 27 orders and 356 families. V.

. *Supplement to the Synopsis of the Extinct Batrachia and ilia of North America;* by E. D. Cope (Proc. Am. Phil. March 3, 1871.)—This paper contains notices of *Sauropleura x* Cope, *Oestocephalus amphiuminus* id., *Colosteus scutellatus* b. (Proc. Ac. N. Sc. Philad., 1856); *Liodon sectorius* Cope osasauroid from the N. Jersey Cretaceous); *Zygorapha micro-ha* id., (of the family Adocidæ) from the New Jersey Cretace- *Catapleura ponderosa* Cope, Cretaceous of N. Jersey; the odilian, *Bottosaurus macrorhynchus* Harlan, from the upper of Cretaceous Green Sand of New Jersey (the *Croc. basitrun-* Owen, in Cope's Syn., p. 65, a species of *Holops*, on p. 231); Dinosaur, *Hadrosaurus cavatus* Cope, from same locality, a es of gigantic size.

. *Animals of Sponges.*—Mr. H. J. Carter, whose researches ponges, confirming the observations of Prof. H. James-Clark, riefly noticed on page 70, has an extended article on the sub- in the Annals and Magazine of Natural History, for July, (IV, viii, 1), illustrated by two plates.

. *On the Homologies of some of the Cranial bones of the ilia, and on the systematic arrangement of the class;* by E. ope. (Proc. Amer. Acad., xix, 194–247.)

III. Miscellaneous Scientific Intelligence.

Note to the Article on a new attachment to the Lantern, age 71. From a letter to the Editors dated, Hoboken, N. J., 8, 1871.—I have just noticed the description of my vertical rn which you have been kind enough to publish in your July , and find that through some inadvertence, a credit has been ted which I have been careful to give on all occasions.

Prof. J. P. Cooke of Cambridge belongs the credit of first ructing a lantern to exhibit horizontal objects by first reflect-he light from the condensers upward by a mirror and then turning the rays to the screen by a silver speculum.

Prof. Cooke kindly showed me this apparatus in operation last summer, and in the instrument which you have described I have simply improved upon his plan with reference to the mechanical arrangement, and, by interposing the first mirror between the elements of the condenser by which I have secured an evenly illuminated and uncolored field of light upon the screen, and by finding that an ordinary glass mirror silvered on the rear surface would answer perfectly well for the final reflection.

To Prof. Cooke is likewise due the idea of thus showing the waves in a tank of water circular or elliptical.

To the experiments already mentioned I have lately added a new one of unusual beauty. By clamping a large square glass Chladni plate so that one corner covers the lantern field, and covering this corner $\frac{1}{8}$ inch deep with water retained by a light ring of rubber, the most beautiful patterns of crispations changing with the change of tone given by the plate can be shown on the screen.

Yours, &c. HENRY MORTON.

2. *Note to the Article on the application of Photography to the determination of Astronomical data;* by ASAPH HALL.—Mr. David Trowbridge of Waterburgh, New York, has called my attention to the fact that Professor Bartlett of West Point, had applied the photographic method to determine the times of contact in a solar eclipse as early as 1854. Professor Bartlett's observations were published in Gould's Astronomical Journal, vol. iv, p. 33.

A. H.

3. *On the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D.—We have from Dr. Morton a paper for the next number of this Journal describing experiments of his which sustain the interesting conclusion that "all the familiar fluorescent solutions, such as the tincture of Turmeric, of Agaric, of Chlorophyl, and the solution of Nitrate of Uranium, emit lights of the same color of fluorescence—namely, blue, identical with that developed by acid salts of quinine.

4. *Indianapolis Meeting of the American Association for the Advancement of Science, Aug.* 16, 1871.—According to a circular issued by the Local Committee, the first session will be held at the Academy of Music at 10 o'clock A. M., when a reception will be extended to them by his Excellency, Conrad Baker, Governor of Indiana.

Members, and those who wish to become members, are requested, immediately upon their arrival, to register their names at the office of the Local Committee, at the State House, where they will be furnished with member's tickets, and such information as may be desired in regard to accommodations, etc. The citizens have signified their desire to extend hospitality to the members. There are likewise ample hotel accommodations, and special arrangements will be made with hotel and boarding house proprietors for reduced rates. It is therefore particularly requested that persons intending to be present, will notify the Local Secretary (Prof. E. T. Cox) by letter, as early as practicable, and when possible, state the day they will arrive.

Jahresbericht über die Fortschritte der Chemie, etc. Unter Mitwirkung von A. Laubenheimer, Al Naumann, F. Nies, F. Rose, herausgegeben von Adolph Strecker. Für 1869. Erstes Heft. Giessen, 1871.

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[THIRD SERIES.]

ART. XXI.—*On the Testimony of the Spectroscope to the truth of the Nebular Hypothesis;* by Professor DANIEL KIRKWOOD, of Bloomington, Indiana.

IN March, 1846, the partial resolution of the great nebula in Orion was announced by Lord Rosse. In September of the following year, the late Prof. W. C. Bond, of Harvard University, stated, in confirmation of this interesting discovery, that the part of the nebula about the Trapezium "was resolved into bright points of light" by the great refractor of Cambridge. "It should be borne in mind," continued Prof. B., "that this nebula and that of Andromeda have been the last stronghold of the nebular theory; that is, the idea, first thrown out by the elder Herschel, of masses of nebulous matter in process of condensation into systems."

These grand achievements were regarded by the majority of astronomers as fatal to the claims of the nebular hypothesis. It is not to be denied, however, that this celebrated theory has more than recovered from the shock which it then received; that it has, in fact, been materially strengthened by the researches and discoveries of the last twenty years. The truth of this remark is strikingly exemplified by the revelations of the spectroscope. The man who at the middle of the nineteenth century would have been bold enough to predict the discovery of the physical constitution of the heavenly bodies, or the determination of the elements of which they are composed, would have been generally deemed a scientific enthusiast. This, however, and more than this, has been actually accomplished. In

the hands of Huggins, Secchi, Young, and others, the *spectroscope*, that marvel of modern science, has yielded satisfactory testimony not only in regard to such stars as are reached by our unassisted vision, but even respecting the telescopic nebulæ, apparently on the outskirts of the visible creation. A detailed account of these wonderful achievements would not comport with our present purpose. Such *results*, however, as bear directly upon the theory of Laplace will be briefly noted.

1. The ring nebula in *Lyra*, the Dumb-bell nebula, the great nebula in *Orion*, and others which might be named, are not, as was but recently believed, extremely remote sidereal clusters; but *their light undoubtedly emanates from matter in a gaseous form.*

2. "According to Lord Rosse and Professor Bond the brighter parts near the trapezium [in the nebula of Orion] consist of clustering stars. If this be the true appearance of the nebula under great telescopic power, then these discrete points of light must indicate separate and probably denser portions of the gas, and that the whole nebula is to be regarded rather as a system of gaseous bodies than as an unbroken vaporous mass."*

3. Progressive changes in the physical condition of certain nebula are clearly indicated by the fact that nuclei have been established which, as shown by their spectra, are not wholly gaseous, but have passed, at least partially, to the solid or liquid form.

4. The spectroscopic analysis of the light of several comets reveals a constitution similar to that of the gaseous nebulæ.

The spectroscope, then, has *demonstrated* the present existence of immense nebulous masses, such as that from which Laplace supposed the solar system to have been derived. It has shown, moreover, a progressive change in their physical structure, in accordance with the views of the same astronomer. In short, the evidence afforded by spectrum analysis in favor of the nebular hypothesis is cumulative, and of itself sufficient to give this celebrated theory a high degree of probability.

ART. XXII.—*Experiments on the time required to communicate impressions to the Sensorium, and the reverse;* by T. C. MENDENHALL, Columbus, Ohio.

I PROPOSE in this paper to give a few of the results of some experiments, carried on during the last fall and winter, having in view the determination of the time occupied in the perception of an object and the response to that perception, by an action performed in the simplest possible manner; also, to estimate the

* Monthly Notices of the R. A. S., vol. xxv, p. 156.

time occupied in some cases in which the action follows the choice of one of two things, or after what might be termed a judgment of the simplest nature. An attempt is also made to determine the relative rapidity with which responses are made to impressions made upon the different senses. My method of proceeding is, briefly, as follows: Time is measured by means of an ordinary register similar to an ordinary form of the astronomical chronograph, in which I have been able to move a slip of paper with great regularity at the rate of about one and a half inches per second, the seconds being registered upon this slip by a second's pendulum according to the electric method. The person on whom the experiment is being made is seated at a table, having his hand on a key; by pressing this with his finger the circuit is completed and the time of this action registered upon the moving band of paper. I made an apparatus by means of which the circuit is completed for an instant, the moment that there appears at a circular opening about three fourths of an inch in diameter a card, red or white as I choose, which completely fills the opening. The subject is instructed to watch this opening, and to close the circuit, by pressing for a moment upon the key, immediately upon seeing the card. The actual appearance of the card and his closing the circuit in response are registered upon the band of paper by two dots, separated by an interval approximating perhaps to one-fifth of an inch. Now by carefully measuring this interval and comparing it with the registered second, I obtain, of course, an expression for the time occupied by the somewhat complex operation of his perceiving the object and acting in response to that perception. I introduce the exercise of judgment by giving him two keys, one for the right and one for the left hand, and instructing that when a white card appears he is to close with his right hand, and when a red card appears he is to close with his left hand. Of course a considerably longer time intervenes between the appearance of the card and his response in this case than in the former, and I have endeavored to express the actual time consumed in making a decision as to the color of the card by subtracting the former result from the latter; since in each case there is the same perception of the card and the same muscular action in response.

I have also placed on white cards two figures, differing in form as much as possible, as a circle and a triangle, operating with them in the same manner as in case of two colors. To obtain accurately the time intervening between the appearance of an object and a simple muscular response, I did not depend upon the experiment with the card, which might involve some sources of error (which if they exist, however, are destroyed by cancellation in the determinations concerning the exercise of

judgment), but I also made a series of experiments in the dark. An electric spark, produced simultaneously with the closing of the circuit, was observed and a response made to its appearance by pressing the finger upon the key. According to the same general plan, with appropriate apparatus I made trials concerning the sense of hearing. I arranged that by pressing upon a key, unseen by the subject upon whom I was experimenting, I could at the same time close the circuit and produce a clear and distinct sound, upon hearing which he made a response, the interval of time being measured as before. I connected my apparatus with the key-board of a piano-forte in such a way that I was able to introduce an exercise of judgment in the comparison of two tones, differing in pitch much or little as I chose. As will be seen in the results, by comparing C with E and also C with its octave, it appears, as musicians generally affirm, that it is most difficult to distinguish a tone from its octave. To study in the same way the sense of feeling, I arranged an apparatus in such a manner that I could hold it in my hand and close the circuit by striking my subject a smart blow upon the head, face or hand, as I might desire. The part of the instrument which came in contact with the skin consisted of a piece of rough, coarse sand-paper about three fourths of an inch square, so that the effect might be as immediate and prompt as possible. In every case two series of experiments were made, one by making the blow upon the back of the hand and another by making it fall about the center of the forehead. Of course the person upon whom I was operating was prevented from seeing or being able in any manner to anticipate the blow. In all of the cases except a single one the result was, as in the example following, that it required less time to respond when the blow was received upon the forehead than when it was received upon the hand. This difference may, partially, represent the time required for transmission of a sensation from the hand to the brain. In the single exception referred to, the anomaly was undoubtedly in part due to a fact afterward communicated to me by the subject himself. He informed me that the back of his hand had acquired by "cultivation" a sensibility greater than usual; that in his occupation—that of a chemist—he continually used it as a means of testing the fineness of powders. With different persons as many as two thousand individual trials have been made and the errors of experiment eliminated, as far as possible, by the method of averages. I give below a table of the reduced results in one case, in which each number is the mean of the results of from forty to eighty trials. As was anticipated, different individuals furnished in some cases strikingly different results, but with the one exception given above, they all followed, I believe, the order of the following:

Case of A. G. F.	Time in seconds.
Response to appearance of a white card,	·292
" " " electric spark,	·203
" " a sound,	·138
" " " touch upon the forehead,	·107
" " " " " " hand,	·117
" when required to decide between white and red,	·443
" " " " " " circle and triangle,	·494
" " " " " " tones C and E,	·335
" " " " " " " C and C above,	·428

Experiments of a similar nature to those which I have here recorded have been made by several European experimentalists, but none, I believe, in exactly the same manner; and as the subject seems worthy of attention I hope to pursue it further.

Columbus, Ohio, May, 1871.

ART. XXIII.—*On the amount of Time necessary for Vision*; by OGDEN N. ROOD, Prof. of Physics in Columbia College.

IN the celebrated experiment of Wheatstone on the duration of the discharge of a Leyden jar, the conclusion was drawn that distinct vision is possible in less than one millionth of a second. The incorrectness of the data on which this conclusion rested was afterward pointed out in an admirable investigation by Feddersen, who remarks on this point: "One cannot hereafter assume, in optical and physiological experiments, that the discharge of a Leyden jar is an instantaneous act; but at the same time, by the determination of the greatest suitable resistance, it will be possible to limit the discharge to its least possible duration."* The smallest measured duration obtained by Feddersen was one-millionth of a second.

In an article in the present number of this Journal I show how, by the use of a much smaller electrical surface, I obtained and measured sparks the duration of whose main constituent was only forty billionths of a second. With their light, distinct vision is possible; thus, for example, the letters on a printed page are plainly to be seen; also, if a polariscope be used, the cross and rings around the axes of crystals can be observed with all their peculiarities, and errors in the azimuth of the analyzing prism noticed. There seems also to be evidence that this minute interval of time is sufficient for the production of various subjective optical phenomena: for example, for the recognition of Loewe's rings (using cobalt glass); also the radiating structure of the crystalline lens can be detected when the light is suitably presented to the eye.

* Pogg. Annalen, Band cxiii, p. 453.

Hence it is plain that forty billionths of a second is quite sufficient for the production on the retina of a strong and distinct impression; and as the obliteration of the micrometric lines in the experiment referred to, could only take place from the circumstance that the retina retains and combines a whole series of impressions, whose *joint duration* is forty billionths of a second, it follows that a much smaller interval of time will suffice for vision. If we limit the number of views of the lines presented to the eye in a single case to ten, it would result that four billionths of a second is sufficient for human vision, though the probability is that a far shorter time would answer as well, or nearly as well. All of which is not so wonderful, if we accept the doctrines of the Undulatory Theory of light; for according to it, in four billionths of a second, nearly two and a half millions of the mean undulations of light reach and act on the eye.

New York, June 30th, 1871.

ART. XXIV.—*On the nature and duration of the discharge of a Leyden Jar connected with an Induction Coil;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

PART SECOND.

IN the first part of this paper* I described certain results obtained with a Leyden jar of moderate size connected with an induction coil; measurements of the total duration of its discharge were given, and it was shown that the luminous effects were mainly concentrated in the *first act*, which was found so short as to be quite immeasurable with the means then at my disposal. As one main object in these experiments was the production of an illumination as nearly instantaneous as possible—the intention being to employ it hereafter in a totally different investigation—it occurred to me that the desired end might be still more perfectly attained by the use of a quite small electrical surface. In the set of experiments above mentioned, the coating of the jar was 114·4 square inches, so this was now replaced by a jar with a coating of only eleven square inches. The sparks it furnished, when connected with the same induction coil, were perfectly satisfactory as regards illuminating power; and I at once proceeded to measure their duration, employing the means and apparatus already described. For the mirror I used silvered glass, the polished *silver* side reflecting the light; its size was half an inch square. The rod figured at W was removed, with of course great advantage to the ve-

* See this Journal, vol. xlviii. Sept. 18'9.

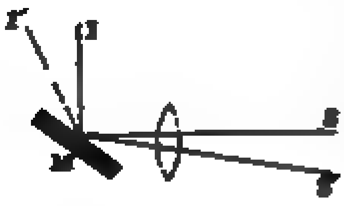
locity; and as several discharges occurred in a second, it was seldom that the weight ran down without at least one good observation being obtained.

With this mirror making not less than 300 turns in a second, I was greatly surprised to find that the image of the spark on the ground glass, as viewed by the naked eye, was quite unaffected in appearance, looking about the same as though the mirror had been stationary. This experiment, which was repeated daily, gave uniformly the same result, and proved that the total duration of the discharge was incomparably shorter than in the case of the larger jar. When the paper with the black lines ruled on it was used, they were seen equally distinct with the highest as well as with the lowest velocities; and all the evidence went to show that the discharge of this small jar consisted of a *single act*, whose duration was immeasurably short. Knowing well the inestimable value in certain physical inquiries of a source of illumination of this character, a series of more deliberate experiments were now instituted for the purpose of examining in detail its nature, and, if possible, duration.

The mirror was made to revolve 300 times in a second, the image received on the ground glass, and viewed with the naked eye, platinum wires $\frac{1}{16}$ of an inch in diameter being used, with a striking distance of five millimeters. The result was as above given, the spark-image being totally unaffected—once only at one of its ends a very small and faint streak was noticed. Replacing the ground glass by plain, and magnifying the image of the spark with an eye-piece, it was now at last certainly ascertained that it was followed by a minute and faint tail or streak situated at its extremities. The illuminating power of this streak was trifling—less than one per cent of that of the unanalyzed body of the spark it belonged to—and its length was hardly much greater than the breadth of the micrometer lines previously employed. The platinum wires were replaced by others of zinc, and, as was expected, the tail was rendered more easily visible, and attempts were made to compare its size with the thickness of single micrometer lines, which proved difficult and uncertain, owing partly to the variable position assumed by the spark-image in the field of the eye-piece. Although for practical purposes the duration of this faint tail or streak is only of slight importance, still for the sake of completeness a new form of micrometer was devised capable of effecting its measurement, and I cannot but hope that the general plan employed may hereafter prove useful in parallel lines of investigation. The point to be gained was to have the micrometer always applied to the object to be measured; the spark-image must carry its own micrometer—must in some way be made as it were to measure itself.

Micrometer.—Let the spark be generated at S, fig. 1; its light, falling on the stationary mirror M, will form a spark-image at I, in the plane of the observing plate. If at the *same* instant a second spark be generated at S′, its image will fall at I′. Let us suppose that during the simultaneous production of the two sparks, the mirror is rotating so rapidly as to be able to draw them partially out into streaks, then we shall have the appearance presented by fig. 2. the distance between I and I′ varying with the original distance between the sparks; and it is evidently possible to diminish this quantity, so that the tail of I should just be in contact with the edge of its companion. In this way, the length of the tail can be measured, it being afterward only necessary to measure on the observing plate the distance of the spark-images apart when seen with the stationary mirror. In actual practice, at S′, I placed a plane mirror, and by varying its inclination with a screw, obtained any desirable separation of the images, without greatly injuring the focal adjustment. A still better arrangement is to remove this mirror, and substitute for it at S′ a small strip of white paper, inclined 45° so as to receive the light of the spark, as its feebler luminosity, straight edge, and the perfection of the joint focus, all tend to increase the accuracy of the results. This paper was supported by an appropriate stand, and was moved till the right distance had been attained.

1.



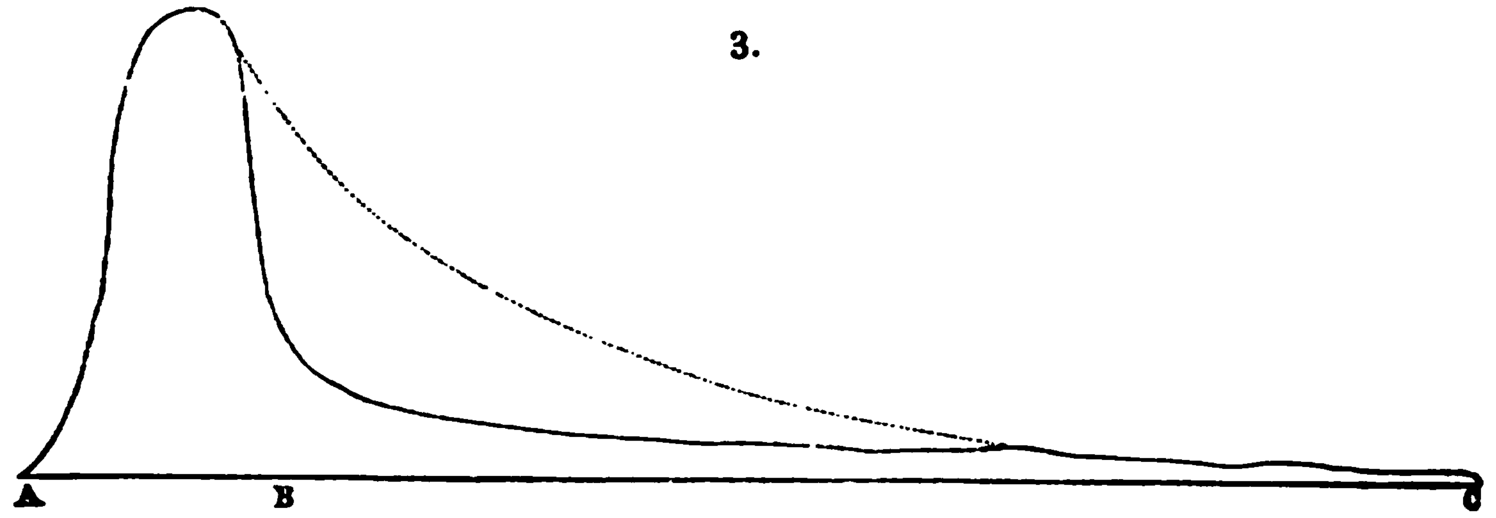
2

Total duration of the discharge.

As was to be expected, this was found subject to some variation in individual sparks. With zinc points, and a striking distance of one millimeter, the duration varied between ·000001 and ·0000025 of a second, a duration as long as two and a half millionths of a second being somewhat rare. With greater striking distances, or with platinum points, the tail was not so well developed; but sets of more hasty measurements showed that its duration in these cases did not widely differ from the figures above given. With zinc points, and a striking distance of *two* millimeters, a couple of careful experiments gave respectively a duration of ·0000022 and ·0000019 of a second. The room in which the determinations were made was usually not entirely darkened, but kept in something of a twilight condition, which is more favorable for preserving the accommodation of the eye; from time to time these results were compared with those obtained in a dark room, but nothing new of importance was thus elicited.

Although with the improved micrometric method above described an interval of time as small as one millionth, or half a millionth, of a second could, as has been sèen, be directly measured, still with its aid I never detected any sign that the *duration of the great body of the spark was other than absolutely instantaneous;* as, however, all the light of the spark is due to incandescent material particles, we must suppose that an infinitesimal portion of time is required for attaining its maximum brightness, and owing to the same reason its disappearance demands another distinct period however excessively minute. Hence, we may represent the luminous effects of the discharge by a

3.



curve conforming more or less to that here figured, in which intensity of light is measured in a vertical, time in a horizontal, direction. This curve then, (the unbroken line), serves to give some idea of the relation existing at successive intervals between the luminosity and duration of a single discharge, and its continuity indicates the fact that there is no real interruption at any moment. The curve is of course adapted for that part of the discharge next to the electrodes, or for electrodes that are near together; for in the case where they are distant five or ten millimeters, the part between B and C is not so well developed.

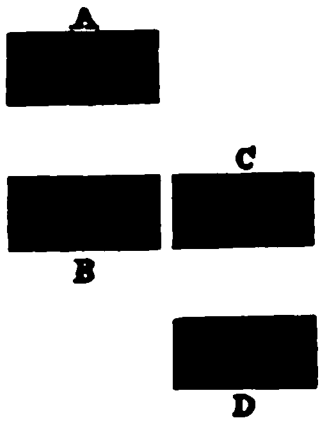
It is this steep peak A B which constitutes what, in the first part of this paper, I have characterized as "the first and most brilliant act of the discharge;" though with a larger Leyden jar (114 square inches), it is neither so steep as in the present case, nor so solitary, being followed by a series of minor elevations, while with a *small jar* the effective luminosity of the discharge is almost wholly concentrated in it. In the present case, then, the far greater brilliancy of the light at the beginning of the discharge practically separates it from what follows, practically constitutes it a first distinct act, and renders its measurement highly desirable. Later, some evidence will be adduced to show that the curve really has a form substantially like that here given, instead of some such one as is indicated by the dotted line.

For the purpose of measuring, or at least setting, a limit at one side of the infinitesimal period of time involved, I employed

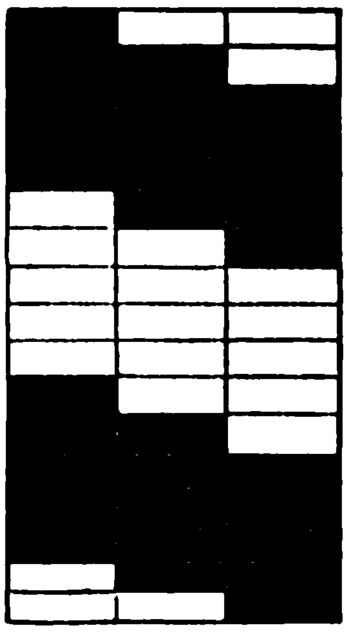
the same general device of black and white lines previously described. But it will now be necessary to make a more *accurate* analysis of their relation to the problem than was given in Part First of the present paper, as I noticed after publication that, owing to an oversight, the statement there printed is partly incorrect, though the results there given are not vastly affected, and may be corrected by reading on the last page, that the discharge was proved to last less than *four*, instead of two, ten-millionths of a second. (Its actual duration I have recently obtained, and state at the end of the present paper.)

If two black lines of a certain breadth, inclosing between them a white line of equal breadth, be illuminated by the spark, and their images formed on the observing plate by the lens and mirror, the three lines will evidently be seen unaltered in appearance; provided, 1st, that the mirror is stationary, or revolving at a sufficiently low rate; or, 2d, the same effect will be produced with a rapidly revolving mirror and a truly instantaneous spark. If, however, the illumination of the spark last sufficiently long so that while A B, fig. 4, represents the first view obtained, the last view shall be represented by C D (moved to the left till superposition has been attained), then, owing to the retention of impressions on the retina, the distinction between the black and white lines will be exactly obliterated, and a tint of gray produced, as can be shown by a construction. In fig. 4 the first and last views *only* are given; but as the action is an unbroken one, we must remember that between them properly belong a great number of pictures, with a gradually increasing displacement. Taking this number, for example, as eleven, then, on completing the construction which is begun in fig. 5 so as to correspond with fig. 4, it will be seen that the result is a gray streak shading into white at its upper and lower boundaries, and that all the interior portions are composed either of resultants produced by adding five parts of black to six of white, or the reverse. And in general, if we set the number of views equal to some odd number greater than unity, we shall obtain for the interior portions $\frac{n-1}{2}$ parts of black, with $\frac{n+1}{2}$ of white, or the reverse; so that the greater the number of views used in the construction, or the more we approach to the real state of the case in nature, the more perfect will be the balance of black and white obtained. And this conclusion is justified by experiment; for if two black sec-

4.



5.



, inclosing between them a white sector of equal breadth, painted on a white circular disc of card-board, and viewed mirror through an aperture cut in the same disc, when it nade to revolve, these sectors will be distinguishable until observing aperture has been widened so that it is equal in adth to *two* of the painted sectors, when only a band of gray be seen, uniform in its interior portions, and shading into te at its two extremities, according to the indications of the struction. Furthermore, making the disc experiment afresh, the observing aperture is gradually widened, it is easy to e the growing obscurity and lack of sharpness in which the ors become involved, which may hereafter serve to interpret responding changes in the image produced by the electric charge, or explain and give a meaning to their absence.

nstead of using only two lines, the same result can far more ly be attained by ruling paper with a large number of fine ck lines, equidistant, and inclosing white spaces of their own adth, as then the chances for observation are greatly multi-d. A construction made on the same plan, for a set con-ing a large number of lines of this character, will show that same law again prevails, that the extremes shade into white, that all the interior portions are of a uniform gray tint; ce, that when a superposition such as indicated in fig. 4 has n obtained, all the lines will, by the retention of impressions the retina, be obliterated. Naturally, experiment with the gives the same result.

Accordingly, I again used the same set of lines (on paper) ntioned in Part First of this article, and illuminated them h the electric discharge now under consideration. With the ror revolving 340 times in a second, using platinum points a striking distance of two millimeters, the lines were still n with an eye-piece, as bright and clear as though the mirror been stationary, implying, as the apparatus was then ar-ged, a duration, for the first act, of less than three ten-lionths of a second, which interval would have been required destructive superposition. Nothing more could be done h paper, and accordingly I covered a glass plate with lamp-ck by smoking, and poured over it a few drops of alcohol, ch, acting like a slight cement, enabled me to rule lines on ith a small dividing engine. After many trials and micro-pic examinations, a plate was produced with lines black and te of equal breadth, and the spark being discharged behind m, they were brightly illuminated. Their image was thrown the observing plate, and by using a sufficient magnifying ver and counting, it was ascertained that the breadth of the ge of a single line, black or white, was $\frac{1}{12}$ of a millimeter. nce, the time required for their obliteration, with a velocity

of 340 per second, was ninety-four billionths of a second (·000000094); still, on experimenting, it was evident that the duration of the discharge was less than this quantity, as the lines were always plainly to be seen.

Duration of the first act of the discharge.

Before finally abandoning the attempt to determine the actual duration of the discharge, another effort was made; a second lamp-black plate was prepared, in which the breadth of the image of a line, black or white, on the observing plate was $\frac{1}{34}$ of a millimeter. These lines were viewed with the terrestrial eye-piece of a small telescope; it enlarged them ten diameters, and care was taken with all the adjustments so that a good clean image should be produced. Platinum wires $\frac{1}{86}$ of an inch in diameter were used with a striking distance of five millimeters. By gradually increasing the weight, it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine, fifty-five billionths of a second; and finally, the lines after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight billionths of a second. In a large number of observations I could detect no discharge lasting during a smaller interval, though the apparatus was now fully capable of making evident much smaller periods of time.

When the striking distance was reduced to one millimeter, the duration was shorter; in the case of $\frac{5}{6}$ of the sparks, the duration was slightly greater than forty-one billionths of a second, the remaining $\frac{1}{6}$ being slightly less than this figure.

With a striking distance of three millimeters, the duration was between forty-one and forty-eight billionths; and when the striking distance was increased to ten millimeters, it was between forty-eight and fifty-five billionths of a second.

An effort was made to make a corresponding set of measurements with brass balls instead of platinum points; and it would seem probable that the duration of the discharge is somewhat increased by their use (or that many of those with shorter durations are suppressed). With brass balls not nearly so many discharges take place in a given time as with points; hence, the work becomes tedious and less certain. The evidence from twenty-six observations, gathered in not less than three hours, went to show that the duration with a striking distance of five millimeters was between forty-eight and fifty-five billionths of a second.

It has thus been shown that the duration of the first act of the electric discharge is in certain cases only forty billionths of a second, an interval of time just sufficient to enable a ray of light to travel over forty feet. This act, however, is only *practically* isolated; from a scientific point of view it is really the distance

A B, fig. 3, which has been measured; and as we are ignorant of the true curve, it might be objected that the real curve might just as well be supposed to be like that given with dotted line. There is, however, experimental evidence to show that this is not the case; for on this supposition, the blurring of the image would begin to be visbile far earlier, i. e., with lower velocities than has been observed. In point of fact, the image remains visibly as distinct as with a stationary mirror till a certain stage, when it begins to be affected, becomes regularly less distinct, and vanishes; between this stage and the final disappearance, there is included an interval of time which is barely accounted for by the gradual superposition of the white and black lines, as I assured myself by parallel experiments with revolving discs, provided with black and white sectors, and an observing aperture of varying size.

Hence it is seen that we have an excellent source of illumination, which has a practical duration of only forty billionths of a second (·00000004); and I am not without hope that it may hereafter be applied to the solution of a number of interesting scientific problems. I may finally add that with another ruled plate, I found it practicable to measure intervals as small as twenty-eight billionths of a second; and the mere act of increasing the focal length of the lens L would admit of the experimenter reaching a quantity as small as ten billionths—probably without much difficulty—though it would be necessary to pay more attention to the correction of the optical part of the apparatus, and the observations would naturally consume threefold as much time.

Duration of the first act, with a Leyden jar having a coating of 114·4 *square inches.*

With the improvements above described, no difficulty was experienced in making this determination, which, as shown in Part First of the present paper, had on a previous occasion defied all my efforts. Platinum points and a striking distance of two millimeters were employed in connection with the coarsest of the three lamp-black plates; but when the mirror made only 183 turns in a second, it was ascertained that the duration of this first act was ·000000175 of a second, or about four times as great as with the small jar and the same striking distance.

New York, June 29th, 1871.

Art. XXIV.—*Memoranda concerning the introduction of the Manufacture of Spelter into the United States*; by Joseph Wharton.

Spelter, as crude metallic zinc is called in commerce, had never before the year 1859, been produced in America upon such terms as to give hope of its manufacture becoming a settled industry in this country.

Mr. John Hitz in 1838 made enough zinc from the ores of the New Jersey Zinc Co., to supply material for a set of standard U. S. weights and measures in brass, but the quantity produced was small, and the cost extremely high.

The Lehigh Zinc Co. caused to be erected in 1856 a spelter furnace at their mine near Friedensville, Pa., upon the Silesian plan; this furnace, though apparently well constructed, failed to yield any zinc, mainly because its builder, Mr. Charles Hoofstetten, was unable to make or to procure any suitable muffles.

Mr. Samuel Wetherill, the patentee of some valuable improvements in the manufacture of zinc oxide, also experimented in a spirited manner upon the production of metallic zinc, and actually produced some at South Bethlehem, Pa., as early as 1858, but though he persevered for about two years, and made a considerable quantity of excellent spelter—in all I think about 50 tons—the cost price was too high, and his enterprise was finally abandoned.*

Some other endeavors of less significance were also made which need not now be mentioned; sundry details relating to the early American history of spelter-making may, however, be found in the New American Cyclopedia under the head Zinc, vol. xvi, pp. 636 and 644.

The present paper proposes to give some particulars, which even at this late day may possess interest, concerning that attempt to produce spelter in this country which really succeeded in establishing the industry here, upon such a footing as to enable it thenceforth to take even rank with other American manufactures in their struggle against European competition.

Having acquired some practical knowledge of the properties of zinc, by several years experience as general manager of the Lehigh Zinc Co's. mines and zinc oxide works, and having also gathered such information as was possible from books and other sources, I made various trials during 1857 and 1858, to invent some form of furnace which should effect the evolution and condensation of zinc vapor in a larger and more continuous way than was practised in Europe, and which should thus

* The first sheet zinc made in America was rolled by Alan Wood & Sons of Philadelphia, from an ingot of Mr. Wetherill's spelter.

fill in a simpler and more scientific manner, what seemed to the easy theoretical conditions of the problem. Some of ›se attempts were not devoid of ingenuity; they cost me ıch toil and money, but they all failed utterly, by reason of having overlooked one or another of what may be called conditions of secondary importance. They served very :le purpose but to instruct me in the real difficulties of the ınufacture, and I revert to them now mainly to point out to younger or more sanguine readers that it is usually very d economy to labor over the rudiments of an art which is to transplanted, repeating perhaps, many futile unpublished periments of its founders, when it is at all practicable for ›m to adopt the processes successfully used elsewhere.

In the year 1859, abandoning these original flights, I built the Lehigh Zinc Co., at South Bethlehem, Pennsylvania, a ıgle spelter furnace of about 45 retorts, upon the Belgian ın and by the aid of several Belgian workmen imported for purpose. Since it was necessary for permanent success that ly conveniently accessible and cheap American materials ould be used, the fuel employed was exclusively Pennsyl-nia anthracite, the retorts and condensers were made by our-ves, mainly from the fire clay of Perth Amboy, New Jersey, d the ore was hydrous silicate of zinc, from the Lehigh Zinc ı.'s mine near Friedensville, four miles south from Bethlehem, ınnsylvania.

This experiment was continued for several months, and was vided into five periods or campaigns. After its close I fur-›hed to the Lehigh Zinc Co., in September, 1859, a report, from ıich the figures below are extracted; these give the average ›ults of the last three of those periods, and show the expen-:ures calculated to the 1000 lbs. of the spelter produced.

The price of ore was here assumed at rather more than the st of mining and hauling to the furnace; the price of coal ıs that actually paid for the small sizes employed, then rela-'ely less valued than now; the wages were of course high, cause but a single furnace was operated, and we were learn-g, viz:

›04 lbs. raw zinc ore at $2.50 per 2,240 lbs.,	$ 4.80
›13 lbs. anthracite coal at $1.75 per 2,240 lbs.,	6.11
ages, including manufacture of retorts, &c.,	20.45
ay, &c., and the preparation thereof,	1.75
›pairs of furnace and tools,	6.00
›am power,	1.00
›nt of buildings,	60
ıperintendance, office expenses, &c., not counted),	
Total cost of 1,000 lbs. Spelter,	$40.71

The entire cost of this experiment, including the importation of workmen, construction of furnace and tools, and all collateral expenses was $3,795.89. The quantity of spelter produced was 34,063 lbs.

That report naturally excited in the minds of the Lehigh Zinc Company, a strong desire to engage at once in the manufacture of spelter, since not only were the technical difficulties in the way of this great prize overcome, and the product of excellent quality, but the cost was within the market price, and there were apparent margins for economizing in several particulars. On the other hand doubts naturally lingered as to the possibility of attaining the expected results upon a large scale, and the financial position of the Company was at that time such as to enforce caution. Both funds and courage were in fact rather lacking, and though I made various propositions, including one to build the desired factory at my own cost, taking pay in a reduction in the price of ore which I would buy to treat in the factory on my own account, no satisfactory arrangement could be immediately made.

Ultimately, however, an agreement was entered into between that Company and myself, on the 13th of December, 1859, by which I engaged for the sum of $30,000, to convey to them a suitable piece of ground in South Bethlehem, Penn., and to erect thereupon by July 1, 1860, a complete Spelter Works, of sixteen Belgian furnaces, each containing fifty-four working retorts; the furnaces to be enclosed in a suitable stone or brick building with slate roof, 155 feet long and 40 feet wide; the establishment to be provided with steam engine and boilers, steam pump drawing water from the Lehigh river, blowers, ore-crushing mill and store room—all these latter to be enclosed in a suitable stone building with slate roof—also to be provided with pottery fully equipped with clay mills and apparatus to make all fire bricks, retorts, condensers, etc., needed in the business, ore-roasting furnaces, air flues and water pipes, railroad into yard, coal bins, etc., and to be in all respects capable of making from the Lehigh Zinc Co.'s selected or lump ores 3,000,000 lbs. of spelter annually. I also bought from the Company 15,000 tons (of 2,352 lbs. each, moist weight) of their selected ore at $7 per ton for the first 5,000 tons, $7.50 per ton for the second 5,000 tons, and $8 per ton, for the third 5,000 tons; the average of which prices was calculated to equal the average price which had been theretofore received for several considerable lots of similar ore, sent by the Company to England. I also agreed to rent the factory to be built as above mentioned, from July 1, 1860 until Jan. 1, 1863 at $3,000, per annum, and at the end of that period to hand it over to the Lehigh Zinc Co., in complete running order for producing the stipulated 3,000,000 lbs. of spelter annually.

arrangement offered to the Company as nearly absolute
;y as the nature of the case permitted, that they should
l expense and without risk or trouble to themselves be
o possession, after two and a half years, of a complete
and an established business, while meanwhile deriving
rofit from the sale of ore, which at that time cost about
ton delivered in the factory yard.*
n my side, relying upon the correctness of my own esti-
nd upon my ability to establish the business, and assum-
it the average price of spelter in this country for the
ng twenty-five years (viz: about 6½ cts. per lb.) would
it maintained for the ensuing two or three years, I could
ount upon a reasonable profit even after making some
ice for mischances.
vere winter prevented much progress in building until
ing of 1860, though one block of furnaces was actually
under cover of a tight temporary wooden building; a
in the spring destroyed the foundations of some of the
s; the thick middle wall separating the backs of the
pairs of furnaces, and supporting the covering arches,
first made of a semi-refractory red brick of the neighbor-
overed on each side toward the furnaces by about 12
of fire bricks; those middle walls melted out, and had to
aced by solid fire brick masonry. In spite, however, of
nd similar difficulties, everything was completed so nearly
ng to programme, that 1,100,580 lbs. of spelter was
n the new factory before the end of the year 1860; a
iich would have been impossible, but for the precaution
I had taken of importing a number of trained Belgian
en, who arrived in August, 1860, about the time the
were completed. As the factory worked irregularly in
r 1860, and the furnaces were brought into use gradually,
ck after another, as they were finished, I give no details
operations for that year.
ndicate what manner of difficulties lie in wait for the
anter of an industry into this country, I may here re-
hat though the factory as at first planned and built was
itially right in all important points, and my estimates of
production were justified in practice, yet a number of
ions to circumstances or partial changes proved to be

i my Reports to the Lehigh Zinc Company, as General Manager of their
l works, I find the cost of zinc ore delivered in the yard of their Zinc
orks in South Bethlehem, which adjoined the Spelter works, to have been
ar ending April 1, 1859, $1.66 9–10 per ton of 2,240 lbs. moist weight,
e year ending April 1, 1860, $1.72 3–10 per similar ton. The average
yses of representative specimens of the ore delivered to zinc oxide works,
s times, shows 26·60 per cent zinc oxide.

necessary: a force of furnace men taken from such laborers as were accessible here, and instructed in the industry, became unruly before they were half trained, and presuming upon their supposed monopoly of the art and my supposed necessities, began to demand extravagant wages and privileges tantamount to control of the works, and were only brought into subordination by the unexpected arrival, in June, 1861, of a second colony of Belgians, whom I had quietly sent for betimes: a manager brought over from England proved unsatisfactory, thus obliging me to take personal charge of everything for the entire term: those dykes against the inundation of foreign spelter, which I had expected from a tariff upon it approaching the average of that upon other imported goods, were prevented by the importers, aided by some American spelter buyers, who disregarded the fact that their interest demanded a home production. Early in 1861, the demand for all goods had become very light in view of the threatening political aspect, and my spelter, though of the choicest quality and a few months before eagerly taken, could not be disposed of except in small quantities and at extremely low prices. A large stock accumulated in my hands, while money with which to continue the manufacture became very scarce.

The factory was, however, driven unremittingly, and its operations during the year 1861 were as follows:

		Per diem per furnace.	Per diem per retort.
Days work of 1 furnace,	4,141¼		
Days work of 1 retort,	223,548		
Retorts consumed in 1861,	12,986	3·14	·085
Condensers " "	34,425	8·31	·154
Raw ore " "	11,994,794 lbs.	2,897 lbs.	53·66 lbs.
Roasted ore " "	9,879,000 "	2,386 "	44·19 "
Fuel coal " (including steam power, pottery, &c.,)	18,948,273 "	4,577 "	84·76 "
Charge coal consumed in 1861,	3,709,350 "	896 "	16·59 "
Spelter produced, "	3,158,630 "	763 "	14·17 "
Per centage yield of ore counted as raw,	26·33 p. c.		
Per centage yield of ore counted as roasted,	31·97 "		
Loss in weight of Raw ore by roasting,	17·63 "		
Ratio of Coal consumed to Spelter made,	7·17 to 1		
Average duration of Retorts in days,	17·21		
Average duration of Condensers in days,	6.49		

The total amount of wages paid for the year, for all purposes except the office expenses, was $44,113.54, or per 1000 lbs. of spelter produced $13.96.

The total cost of spelter in 1861, including not only ore, coal, pottery materials and wages, but also rent, repairs, contingent and office expenses—every outlay in fact except selling expense—was $34.70 per 1000 lbs. at the factory. The net average price received for spelter sold in 1861 was $42.97 per 1000 lbs. at the factory.

e year 1862 the supply of ore was of somewhat inferior yet by the sliding scale of price payable under the it cost more per ton than in 1861; these disadvantages eutralizing those economies which greater experience tinual diligence rendered possible.

ost of spelter in 1862, including as in 1861 all items of except interest on working capital, but excluding sell-enses or any allowance for my own exertions, was ɔer 1000 lbs. at the factory.

articulars of operations for 1862 were as follows:

		Per diem per furnace.	Per diem per retort.
rk of 1 furnace,	4,705		
rk of 1 retort,	258,509		
ɔonsumed in 1862,	13,614	2·89	·053
ers " "	47,870	10·17	·185
" "	14,209,169 lbs.	3,020 lbs.	54·91 lbs.
ore " "	12,532,130 "	2,664 "	48·44 "
l " (including steam engine, y, &c.,)	26,451,844 "	5,622 "	102 22 "
l " (in Spelter furnaces alone,)	22,236,164 "	4,726 "	86·02 "
ɔal "	5,296,256 "	1,126 "	20·47 "
racting material consumed,	1,974,919 "	420 "	7·64 "
do. " (broken ɩ, &c.,)	1,039,132 "	221 "	4·02 "
ɔroduced in 1862,	3,704,676 "	787 "	14·31 "
age yield of ore counted as raw,	26·07 p. c.		
age yield of ore counted as roasted,	29·56 "		
weight of Raw ore by roasting,	11·80 "		
Coal consumed to Spelter made,	8.57 to 1		
duration of Retorts in days,	18·99		
duration of Condensers in days,	5·40		

ıl amount of wages paid in 1862 for all purposes ex-ce expenses (and for brick-making as below stated) was 09, or, per 1000 lbs. of spelter produced, $12.96.

bove figures, showing coal and refracting material used, ges expended, as also the sum stated for total cost of in 1862, include the fire bricks of all sorts used in re-l of which were made on the premises, but do not in-penditures, receipts and materials for 95,630 fire bricks ı the works beyond its own requirements and sold to tablishments at a slight profit.

maller loss of weight by roasting in 1862 than in 1861, ller difference in yield as calculated on the ore when when roasted, and the increased consumption of coal, ɪm the fact that the proportion of carbonate of zinc ppeared in the ore of 1861 did not exist in that of 1862; r being almost exclusively silicate of zinc, an ore more y and poorer than the carbonate, and having nothing ɔy roasting but water.

ease of the factory was extended from January 1, to 1863, in order to compensate for certain deficient de-

liveries of ore. On the latter date I surrendered possession to the Lehigh Zinc Co., and have consequently no later statistics than those above given except for the months of January, February and March, 1863, whose details resemble those of the preceding periods so closely that I will give here only the leading figures, viz:

Raw ore consumed in	first three	months of	1863,		4,184,544	lbs.
Charge coal	"	"	do.	"	1,349,880	"
Fuel coal,	"	"	do.	"	7,083,798	"
Spelter produced,		"	do.	"	986,080	"

A resumé of the spelter produced during the entire term shows it to have been in the fraction of 1860, 1,100,580 lbs.

during the year	1861,	3,158,630	"
" "	1862,	3,704,676	"
" 3 months of	1863,	986,080	"
	Total,	8,949,966	"

This weight being not that shown by the daily furnace statements, but the weight actually sold and delivered to purchasers.

I am aware that to give the details here presented their full scientific or technical value, they should be accompanied by reliable statements of the composition of the ores treated, and of the slags thrown out, but no continuous series of analyses was made of either ores or slags, since my duties as superintendent, bookkeeper, and business manager of the establishment prevented a very close attention to its chemistry. Among my analyses, however, are those of 5 specimens of ore at various times in 1859 and 1860, which were of such a nature as to be fairly presentable for samples of the ore treated in the spelter works: these five specimens show an average of 36·07 per cent metallic zinc.

It is to be remarked that these analyses, and also the weights given above of raw ore consumed, are of the moist ore as received from the mine. The moisture in a large quantity of ore set apart as a sample of that to be delivered at the spelter works was 5·53 per cent, but this is less than was sometimes present, particularly in the year 1861 and the spring of 1862.

Nine specimens examined for moistцre at various times, and representing with considerable fairness the ore delivered in the last named periods, show an average moisture of 8·83 per cent.

Of slags, I find only two reliable analyses; one made in November and one in December, 1860; from their proximity to each other in time, and from their occurrence in the earliest working of the establishment, they can hardly be presented as representative specimens. It is not, however, to be doubted that the slags were always tolerably rich in zinc, since of the ore treated probably at least $\frac{3}{4}$ was silicate of zinc, only the remaining fraction being carbonate of zinc.

The two slags named do not differ widely, and average 11·46 r cent. metallic zinc.

It seems inexpedient to burden this paper with descriptions furnaces, apparatus or processes, since all were but copies, ghtly modified to fit local circumstances, of the well known lgian furnaces, apparatus and processes. The figures given ll enable the metallurgist to compare my results with those other establishments, while the general success of the enter- ise, in face of the oracular opinions of interested experts that ıc distillation required the lambent flame of bituminous coal, d could not be effected with anthracite, that silicate of zinc d not been and could not be made to yield any considerable rt of its metal, and that no American clays were capable of thstanding the peculiar trials of a zinc retort, may serve to courage some of my countrymen in their attacks upon other ıropean monopolies.

A few details of my experience in construction may be use- . Excluding the stone foundation, the air flues leading to naces, the cast iron ingot moulds, and the sheet iron charge xes, each block of 4 furnaces required the following materials, ; :

Ordinary red bricks,	13,000	
9 inch fire bricks,	11,000	
Fire bricks of special patterns,	71,364	lbs.
Cast iron for furnace fronts, doors, braces, &c.,	37,320	"
Wrought iron for straps, bolts, &c.,	1,138	"
Wrought iron for tools (plus 22 lbs. cast steel)	1,267	"

In considering the statements of cost given in this paper, the .der must bear in mind that it is not now possible either to ild, or to produce spelter, so cheaply as was done in the years 30 to 1863, and this not only nor principally because I con- cted the business with unusual assiduity and maintained a ;h standard of efficiency and discipline among the workmen, t mainly because labor is now much higher than it then was, l because no ore of equal quality can now be obtained so eaply in a spot so favorable for its manufacture.

The quality of the spelter made in this establishment has rays been excellent, and has caused it to be preferred above other sorts for zinc castings, and for all purposes requiring a ;h degree of purity. In the exhaustive examination of rious kinds of zinc, communicated in May, 1860, by Drs. arles W. Eliot and Frank H. Storer, to the American Acad- y of Arts and Sciences, my zinc was found to excel all ıers; the sample No. 4 there mentioned was made by me in year 1859, in the trial furnace spoken of in the earlier part this paper.

The Lehigh Zinc Co., since taking possession of the factory, have maintained the high character of its product, and the zinc-rolling mill which they have added to it turns out sheet zinc of the very choicest quality, such as could only be made from spelter of the highest grade.

This excellence results mainly of course from the unusual purity of the ores of Saucon Valley; the silicate particularly, which has always been the predominant ore there, being notably freer from impurities, not only than most ores from other localities, but also than the carbonate which abounded in the earlier history of those mines, or the sulphide which appears more and more as the depth of the workings increase.

At one time, in order to produce a certain quantity of superior zinc for chemical uses, I selected a quantity of the cleanest silicate of zinc, calcined it in a new roasting furnace, rejected, after roasting, all pieces which from discoloration or otherwise appeared suspicious, ground it in a clean mill, and then distilled it in a furnace which had never before been used, rejecting all the first and last products of distillation from each charge in each retort. The zinc thus made, amounting to several tons, went mostly to various chemists, and is doubtless all consumed except a few ingots which I still retain. It was, however, no purer than that examined by Drs. Eliot and Storer, nor is this surprising, since the latter was made in a new furnace from silicate of zinc which had been weathered for a long time, and was thus freed from the intermingled clay which otherwise might have yielded some impurities.

The establishment whose origin is thus sketched is still in successful operation, and though its activity is now limited by reason of an insufficient supply of ore, there is good reason to believe that this difficulty will be overcome when the magnificent pumping apparatus now being erected by the Lehigh Zinc Company shall enable them to mine at greater depths.

The entire spelter and sheet zinc manufacture of the United States, now a large and growing industry, may fairly be said to have sprung from this factory, for not only was it the pioneer in point of time by at least two years, but I believe that neither of the others succeeded until it availed itself of the services of men procured from this establishment.

ART. XXV.—*The Daily Motion of a Brick Tower, caused by Solar Heat;* by Prof. C. G. ROCKWOOD, Ph.D., Bowdoin College.

THE observations which form the subject of the following discussion were made in the spring of 1866. Some recent notices of an attempted investigation of the effect of solar heat upon the dome of the Capitol at Washington have induced the publication of the present note; which, though not a perfectly satisfactory solution of the question, it is hoped may still possess some interest, as being, so far as I am aware, the most accurate investigation of the subject that has been made.

The observations were conducted in the south tower of the Sheffield Scientific School in New Haven, Conn. This tower was built during the winter of 1865, but was still unfinished in April, 1866, when these observations were commenced, although all the brickwork was completed. The stuccoing of the outside was not finished until June 1, and during the whole time occupied by the investigation, the presence of the workmen, with scaffoldings, etc., although not vitiating the truth of the results obtained, was a hindrance to that perfect success which might be expected from a repetition of the experiments under the more favorable conditions of a completed tower and more delicate instruments.

The structure in question is a square brick tower, stuccoed on the outside, the exterior surface being much broken up by recessed windows and various architectural adornments. The general plan of the building precluded the use of solid masonry in the tower, which would have been desirable for any structure designed, as was this, to support astronomical instruments. The walls were, however, made unusually heavy, and in order to have as firm a base as possible for the telescope, the upper story was arched with brick, forming a solid and pretty firm brick floor, upon which now rests the stone pier of an equatorial.

The whole tower is surmounted by a revolving wooden turret. The story below the observatory, and immediately beneath the brick arches, is occupied by the works of the tower clock.

The dimensions of the tower are as follows:

Side of the square at ground,	16½ feet.
" " " top of brickwork,	15 "
Thickness of walls at first story,	27 inches.
" " " top of brickwork,	16 "
" " where the arches spring,	20 "
Height to top of turret,	90 feet.
" " brickwork,	80 "
" floor of observatory room,	75 "

The tower is connected by its north side with the main building for an altitude of about 45 feet. Projecting from the south side of the main building, it has its north wall in a line with and forming part of the south wall of the building. The whole edifice stands in a position inclined to the meridian, the sides of the building, and consequently those of the tower, having the direction N. 28° 30' E.

Previous observations elsewhere (at Bunker Hill Monument) had led to the apprehension that such a tower, besides being subject to tremors communicated from the ground, would have a definite and somewhat regular daily motion, dependent upon the influence of the sun's heat in expanding the materials of which it was composed. The object for which this investigation was undertaken was to ascertain whether this motion would affect the use of the telescope or not.

In order to investigate the motion in the present case, two levels were placed at right angles with each other, upon a flat stone embedded in the brick floor of the observatory room (to avoid any undetermined changes which might affect the woodwork), and their indications were recorded from time to time. Any tipping or motion of the tower would of course change the plane of this floor by the same amount, and would be shown by a corresponding motion of the bubble of one or both of the levels. The levels used were:

I. The striding level of a small transit instrument, the property of Prof. C. S. Lyman. This level, supported by its iron stand, was placed parallel to the *front* of the tower, and therefore, approximately east and west. It was read by a scale graduated to hundredths of an inch. Examination with a level-trier gave 1 inch = 39''·37 as the value of its divisions.

II. An unmounted Ertel bubble, which rested directly upon the stone, being placed parallel to the *sides* of the tower, and so approximately north and south. It was read by a scale of tenths of an inch, graduated upon the glass, and reading by estimation to hundredths. Prof. Lyman had previously determined the value of the divisions of this level at 1 inch = 51''·7, which was adopted in reducing the observations.

The levels were recorded six times during the day, at intervals of about $2\frac{1}{2}$ hours; the first record being between 7 and 8 A. M., and the last between 10 and 11 P. M. The series extended, with some omissions, from April 24th to July 7th; but some of the records being afterward rejected as unreliable, the final results were obtained from the discussion of observations upon 59 days, included between April 24th and July 2d, 1866. It will be noticed that about one-half of this period was before the stuccoing of the tower was completed; and during about two weeks, from May 15th to June 1st, the tower was partially shaded from the sun by the scaffolding necessary to this work.

third level placed with the others upon the stone floor, also the levels of a zenith telescope, which was temporarily nted on a brick pier in the room, were recorded during a of this time, but as their results were not employed in the ussion, it is not necessary to notice them farther than to that in general they confirmed the indications of the prin- l levels.

et us now examine briefly what would be the probable ion of a tower thus situated, and then compare this theoret- result with that given by the recorded level readings.

irst: suppose an isolated symmetrical tower of homogene- material, situated at the equator of the earth, and the sun he equinox. The diurnal circle of the sun then passes ugh the east and west points of the horizon and the zenith he tower. In the morning the heat of the sun's rays would ind the east side of the tower, and cause it to lean toward *west*. As the sun rose toward the zenith, and warmed illy all parts of the tower, it would gradually return to nean position. In the afternoon, as the east side lost its by radiation and the west side was warmed by the declin- sun, it would lean toward the *east;* and during the night ld return again to the mean position. Thus the motion ld be back and forth over a straight east and west line.

gain, suppose the same tower situated at the pole. Then, e the sun's rays strike it during the whole twenty-four hours, always at the same angle, the tower, leaning always from sun and always to the same amount, would follow the sun s diurnal revolution, its top describing a circle about its nal position.

t any station intermediate between the equator and the , the figure described by the tower would be neither a ght line nor a circle, but between the two, i. e., an *ellipse*, se excentricity diminishes as the latitude of the place eases.

1 the case under discussion, the tower is in N. lat. 41° 19′, the sun was near the summer solstice. The sun therefore about 30° north of the east point, culminated south of zenith, and set north of west.

he inclination of the tower, being opposite the sun, would in the morning southwest and west, at noon north, at even- east and southeast, and during the night it might be sup- d to return in a straight line to its mean position. Since sun's rays strike the perpendicular sides of the tower more quely at noon than at morning and evening, the northward nation would be less than the westward or eastward, and curve described would resemble an ellipse, with its minor in the meridian, and probably somewhat flattened on the h.

This tower also is not symmetrical nor isolated. It may be considered as a right parallelopiped, standing with its sides inclined to the meridian, and for half its height joined by one side to a large building, which, so far as any effect of the solar heat is concerned, may be regarded as fixed. One side of the tower being thus firmly held by its connection with the building, any motion *toward* or *from* the building would be simply *checked* or *retarded* without change in direction; while to any motion at right angles to this would be added another element, a motion in *azimuth* or a *twisting* of the tower about a vertical line. A scale was prepared in a distant steeple, and the zenith telescope already mentioned was directed upon it, with a view to determine any such azimuthal change. The observations with this arrangement showed a probable daily change of 8″ or 10″ in azimuth, but the instability of the telescope and other causes so far impaired their value, that it was not thought best to incorporate them in this discussion.

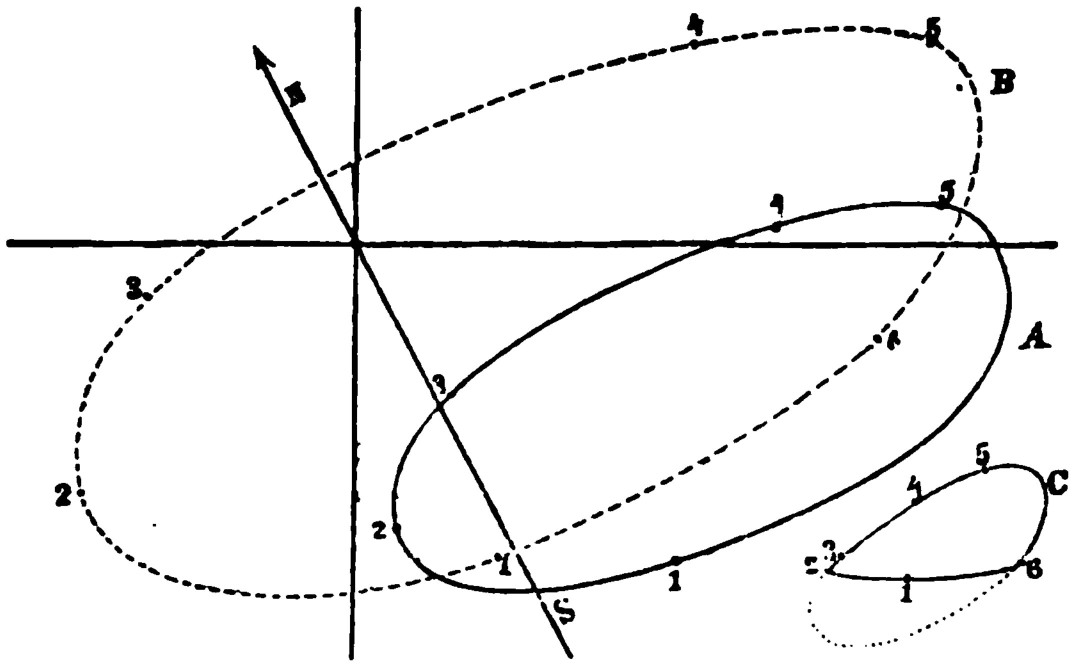
The recorded observations give a series of level-readings at certain hours upon 59 days. The most obvious method of combining them is to take the mean of the readings for all the days, as representing the probable motion of the tower for any one day. Thus combined, the means are as follows, the levels being designated by the numerals I and II, and the level readings having been reduced to seconds.

Mean Level Readings.

+East. I.	−5″·76	−0″·95	−1″·57	−7″·62	−10″·67	−10″·48
+North. II.	+5″·64	+5″·03	+2″·97	−0″·37	− 0″·78	+ 3″·36

If now we let these numbers be the abscissas and ordinates of a plane curve, referred to rectangular axes in the direction of the levels, this curve will be the figure described daily by the normal to the plane of the levels or by any vertical line of the tower. It should also be borne in mind that a *south* level reading indicates a *north* inclination of the tower, and vice versa; therefore, to represent the actual motion of the tower the signs of the above means have been changed throughout in plotting the curve. The curve thus obtained is the one marked A in the figure, the points given by the observations being marked by the numerals 1, 2, 3, etc., in order, beginning with the morning observation. It is seen to be an imperfect ellipse, with a major axis of about 12″ and a minor axis of about 5″, and the minor axis coincides nearly with the meridian. It thus corresponds tolerably with what had been anticipated. But the minor axis of the ellipse is not exactly in the meridian, and the curve is somewhat flattened on the southwest and northeast. Apparently the connection of the tower with the main building has checked the north and south motion, and so shortened

somewhat the extreme ordinates; as we see that by simply lengthening the ordinates on the northeast and southwest, the curve may be made symmetrical and its minor axis be brought into the meridian.



But it is evident that, in anything which depends so directly upon the sun's heat, the average of *all* days will not give a true result. It is necessary to make a distinction between *clear* and *cloudy* days. From the records of the weather, the observations were therefore separated into two classes, viz: days more than one-half clear and days more than one-half cloudy; and there were found 35 of the former and 24 of the latter. The level readings of these two classes were then tabulated separately, and the mean readings taken as before, to represent the probable motion of any one clear day or cloudy day. The mean readings of the two tables, with the mean times of observation, were as follow:

Mean Level Readings—Clear Days.

	7h 50m A. M.	10h 38m A. M.	0h 59m P. M.	3h 32m P. M.	5h 58m P. M.	10h 39m P. M.
+East. I.	−2″·72	+4″·79	+3″·52	−5″·96	−10″·17	−9″·33
+North. II.	+5″·52	+4″·48	+1″·08	−3″·55	− 3″·86	+1″·61

Mean Level Readings—Cloudy Days.

	7h 47m A. M.	10h 39m A. M.	0h 59m P. M.	3h 33m P. M.	6h 3m P. M.	10h 47m P. M.
+East. I.	−9″·94	−8″·60	−8″·65	−10″·15	−11″·43	−11″·98
+North. II.	+5″·82	+5″·76	+5″·59	+ 4″·49	+ 3″·91	+ 5″·65

These averages, with the signs changed, being made abscissas and ordinates, give the two curves marked B and C, the observations being indicated by numerals as before.

We see at a glance how necessary to a true result was the separation into two series. The two curves have indeed the same general form, but how different their sizes and positions. For clear days the longer axis is about 17″, while for cloudy days it is not more than 4″. The curve for clear days shows the same shortening of the ordinates that was noticed in A, though to hardly so great an amount. But the curve for cloudy days is very much distorted, and no longer resembles an ellipse.

This excessive departure from the normal ellipse can not be attributed solely to the connection with the main building, for

any such retarding effect as has been supposed should be greater when the absolute amount of motion was greater, and therefore, should be more evident on the curve for clear days.

An examination of the figure will, however, suggest another, and probably the true explanation. All the points *known* in the curve under consideration, except the one given by the *morning* observation (marked 1), may be found upon a curve nearly similar to the one for clear days. And the distorted position of this point may be accounted for by the supposition (which in fact should not be unexpected), that on a cloudy day the sun would not affect the tower *so early in the day* as on a clear day. Consequently, when the effect begins to be perceptible, the sun has already passed the prime vertical so far as to shine very obliquely upon the northeast side of the tower, and therefore the tower inclines but very little to the southwest of its mean position, and the corresponding part of the ellipse is wanting.

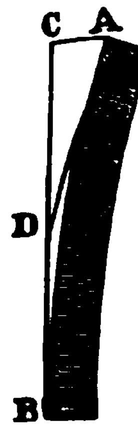
Again, the curve for cloudy days lies considerably farther south and east than the other, instead of being concentric with it. As the south side of the tower is the one most affected by the sun's heat, and moreover has nearly twice the free altitude of the northeast side, it might naturally be supposed to expand most under the influence of the sun's rays; and this, combined with the connection of the northeast side with the building, and its inclination to the meridian, would throw the curve for clear days to the north and west of the other, as it is found to be. It is noticeable also that on clear days the tower is thus maintained out of its normal position by a considerable amount.

Still more, the mean inclination of the sun's rays to the vertical lines of the tower at noon, on the days classed as clear, was 21°, and supposing the intensity of the sun's heat to vary as the sine of the inclination, the minor and major axes of the ellipse should be to each other as sin 21° to sin 90°, or as 35 to 100. Now the minor axis is about 7″, hence the major axis should be from this cause about 20″. It is really about 17″, a discordance which I think can not be considered great, when it is remembered that the tower, being more or less shaded by trees, etc., could not, even on a clear day, be affected by the sun, until the latter had risen some distance above the true horizon (for which the above proportion is calculated), and that the inclined position of the tower to the meridian would probably also affect this element.

The curve deduced from the observations is thus seen to exhibit a sufficient degree of correspondence, with what had been anticipated from theoretical considerations, to confirm the truth of the reasoning: the departures from the perfect ellipse being no greater than can be ascribed to the unsymmetrical position of the tower, its connection with the main building, and other disturbing causes. In all this discussion the varying

powers of absorption, radiation and conduction of the materials of the tower have been left entirely unnoticed. They would undoubtedly have their place in a complete investigation, but no data were at hand for estimating their influence.

If we may suppose the tower to be equally expanded in all parts of its height, the vertical side would be changed into a uniform curve, as AB in the figure; and since the deviation from a vertical is small, the tangent at A would cut the vertical line BC nearly at the middle point between B and C. Therefore CD is nearly one-half the height of the tower, and CA, the distance which the top is moved from its normal position, would be represented by CD $\times$ sin CDA $=\frac{1}{2}$ height $\times$ sin of observed change of level. This gives for the length of CA on an average clear day, 87·5 feet $\times$ sin $8''\cdot5 =$ ·0185 inches, or 2.CA $=$ ·037 inches, the major axis of the ellipse.



But for obvious reasons the upper part of the tower would probably be most affected by the heat; hence CD should proba bly be taken somewhat less than one-half the height, and the major axis of the ellipse should be proportionately diminished.

As an indication of the accuracy of the results obtained from such a series of level readings as the above, it may be remarked, that two days, which in the reduction of the tables were noticed as showing unusually large easterly and northerly inclinations, were afterwards found, by reference to the weather record, to have been marked respectively by a northeast storm and a cool north wind. The effect of the cold rain or wind in causing contraction of that side upon which it blew was thus plainly recorded by the level, and a good illustration afforded of the accuracy of which this method of investigation is susceptible.

In regard to the practical bearing of this discussion upon the availability of such towers for mounting astronomical instruments, it may be sufficient, without entering into details, to state the conclusion arrived at in the present case. This was, that the motion of the tower was so great and so uncertain as to make it unfit for the support of a meridian instrument, but not great enough to seriously interfere with the differential measurements for which an equatorial is principally used. The mean hourly change was not more than $1''\cdot2$, which, during the few minutes of an observation, would be insignificant unless extreme accuracy was desired, and might be combined with the unknown accidental errors in reducing the observations.

In conclusion, I would express my thanks to Profs. Newton and Lyman of Yale College, to whom I have been indebted for the use of instruments and for valuable suggestions in the conduct of the observations.

Brunswick, Me., July 11th, 1871.

ART. XXVI.—*On the destructive Distillation of Light Petroleum Naphthas, at comparatively low temperatures;* by S. DANA HAYES, State Assayer of Massachusetts.

UNDER the generic term *naphtha*, as applied to some of the distillates obtained in the arts from petroleum, is included a series of hydrocarbons having specific gravities above 0·742, or between 0·625 (rhigolene) and 0·742 (heavy naphtha), and boiling points varying with the densities from 65° F. to 300° F. These naphthas have distinguishing characteristics by which they are easily recognized and which place them in a class by themselves; and aside from their odors, densities, boiling points, volatility, and solvent powers, a noticeable peculiarity is the absence of *oily* bodies: they do not leave any permanent stain on common writing paper that has been dipped in them, as do all the heavier and oily distillates obtained from petroleum. The redistillation of these naphthas under different conditions produces other hydrocarbons, in which the proportions of hydrogen and carbon are not only changed, but some of these products are *oils* that will stain writing paper like fats, and it is possible to produce crystallizable paraffine from these volatile naphthas by properly conducted distillations.

In the summer of 1861, the writer had occasion to redistill several thousand gallons of light petroleum naphtha, which was entirely free from oily bodies, in cast-iron "stills," heated directly by coal fires and having powerful condensors attached, such as were then common in coal-oil refineries; and it was observed that besides the gases, light vapors, and a greatly diminished volume of naphtha, an unexpectedly large proportion of heavy paraffine oils was obtained; and after the distillations were finished, large masses of separated carbon were found in the stills, as in the ordinary destructive distillations of crude petroleum, or its heavy products.

In 1862,* Professor Bacon of Harvard Medical College observed, when examining a sample of "keroselene," a light naphtha, that had a "specific gravity of 0·640 at 72° F., and when heated in a flask containing scraps of platinum foil, it began to boil at about 85° F. As the more volatile parts distilled off, the temperature continued to rise, and at 170° about three-quarters of the liquid had evaporated. It continued to boil freely, but the whole was not converted into vapor until the thermometer had risen considerably above 300°. It is remarkable that keroselene should be so readily and completely volatile at atmospheric temperatures. I found that keroselene and Squibb's ether, exposed in watch glasses, lost equal weights

* This Journal, Sept., 1862.

ı two and a half and three and a half minutes respectively; ɑd the former evaporated completely in about two-thirds of ıe time required for the other."

This peculiarity of petroleum naphtha has been so often ob- ɜrved in my laboratory, that I have learned to avoid the em- loyment of heat when evaporating solutions, or extracts made ɑ them, for the purpose of obtaining the substances dissolved; ecause, although these hydrocarbons are exceedingly diffusive, nd evaporate entirely and very rapidly in the air at common emperatures, yet when heated above their boiling points (above 5° F., in the case of keroselene), they undergo destructive .ecomposition, or, if in a flask, destructive distillation, heavier ily bodies being produced which are difficult to remove from he residuum of such evaporations.

Within the past year an apparatus has been erected in Boston, y Mr. Z. A. Willard, for generating gases and hydrocarbon apors for use in metallurgical operations, that has offered an pportunity to obtain considerable quantities of the oils made rom naphtha, distilled at temperatures below 300° F., and I ave examined these products with much interest.

Willard's apparatus consists of three or more upright wrought- ron cylinders, having a capacity of several hundred gallons ach, standing near a common steam boiler, and which are con- ected together and with the boiler by pipes that enter at the ottom of each cylinder, ending there and starting out from the op of each again to connect with the bottom of the next; it is hus a system of large iron Woulfe's bottles, the first being con- ected with a steam boiler. These cylinders or gas generators, when in operation, are about half full of gasoline or petroleum aphtha of the lightest and cheapest kind, which leaves no per- manent stain on note paper, while steam at common working emperature and pressure is passing in at the bottom of the irst cylinder, bubbling up through and vaporizing the naphtha, hen passing into the other cylinders with the same action. The cylinders are provided with glass tube guages, so that the hanges occurring inside may be watched, and the whole appa- atus and contents are maintained under a pressure of about ifty pounds to the inch when in operation.

In this apparatus the steam and naphtha vapors are held to- gether in the upper part of the cylinders, above the liquid, ınder pressure, and at a temperature of about 212° F., or nuch above the boiling point of the naphtha, but never so high ɪs 300° F.; and the decompositions occur in the vapors ather than in the liquid, light uncondensable gases and vapors assing upward, and heavy oil falling down into the naphtha elow. The apparatus was operated continuously by pump- ng in naphtha at intervals as it was consumed, and after the

heavy oil had accumulated it was drawn off at the bottom, the largest quantity being found in the first cylinder. It was found that the longer the vapors were held together in the apparatus, heated and under pressure, the more perfect were these decompositions; and Mr. Willard obtained at different times from two to ten per cent. of the naphtha as heavy oil.

The heavy hydrocarbon oil obtained in this way has a dark yellowish-brown color, and smells of the adhering naphtha when fresh; but after standing exposed to the air for a few days, it loses this odor and becomes nearly neutral, or comparatively free from offensive odor. Its specific gravity varies from 0·850 to 0·860, and its boiling point, after it is freed from the adhering naphtha, is above 400° F.

It does not evaporate at common temperatures, leaves a permanent greasy stain on paper, is a good lubricator for machinery, and when redistilled at high temperatures, it breaks up into lighter and heavier liquid hydrocarbons, paraffine, and separated carbon. It is essentially a paraffine oil, like that of the same density obtained directly from petroleum, or its heavy products, by distillation.

When refining petroleum for illuminating purposes, it has been desirable to break up the heavier products and convert them into the light hydrocarbons generally known in commerce, in this country, as "kerosene"; and several forms of distilling apparatus have been devised for this purpose, in which the vapors of these bodies, by being heated above their boiling points, are decomposed or "cracked," first into burning oil and heavy products, and ultimately into burning oil entirely. But Mr. Willard's apparatus demonstrates that light petroleum naphthas, and probably distilled naphthas from coal and other sources, may be "cracked" at a temperature below 300° F. into lighter and heavier products, the latter being paraffin oils that belong to a class of hydrocarbons entirely different from that of the original naphtha.

Through the kindness of Prof. B. Silliman, I have received a copy of his report on the "petroleum from Venango county, Pennsylvania,"* since the first part of this article was written. It is a memoir that has never been published in any scientific journal, containing the results of an extended investigation made in the spring of 1855, being undoubtedly the earliest record of any chemical research on the distillations of this petroleum. And I take the liberty of quoting from it, because at this early date Prof. Silliman found that the products obtained from petroleum are not simply bodies previously existing in the petro-

* Report on the Rock Oil or Petroleum from Venango county, Pennsylvania, with special reference to its use for illuminating and other purposes. By Prof. B. Silliman, Jr. New Haven, 1855.

eum, but that they are new substances formed by heat and listillation.

The author says: "The uncertainty of the boiling points inlicates that the products obtained at the temperatures named ibove were still mixtures of others, and the question forces itself ipon us, whether these several oils are to be regarded as *educts*, or whether they are not rather produced by the heat and chemical change in the process of distillation. The continued application of an elevated temperature alone is sufficient to effect changes in the constitution of many organic products, evolving new bodies not before existing in the original substance." And further on in the report: "The paraffine, with which this portion of the oil abounds, does not exist ready-formed in the original crude product, but it is a result of the high temperature employed in the process of distillation, by which the elements are newly arranged." When describing the properties of the illuminating oils distilled from this petroleum, Prof. Silliman states the result of an experiment as follows: "Exposed for many days in an open vessel, at a regulated heat below 212°, the oil gradually rises in vapor, as may be seen by its staining the paper used to cover the vessel from dust, and also by its sensible diminution. Six or eight fluid ounces, exposed in this manner in a metallic vessel for six weeks or more, the heat never exceeding 200°, gradually and slowly diminished, grew yellow, and finally left a small residue of dark brown, lustrous-looking resin, or pitchy substance, which in the cold was hard and brittle. The samples of oil employed were very nearly colorless. This is remarkable when we remember that the temperature of the distillation was above 500° F."

It is remarkable that in this early laboratory investigation Prof. Silliman should have noted the production of entirely new bodies by the destructive distillation of petroleum, such as are now only produced in large quantities in manufacturing operations. The "cracking" of petroleum, as a necessary result of its distillations in the large way, was not generally recognized or admitted for several years after this report was written, and even now there are many chemists who consider these as simply *fractional* distillations; but it is only necessary to mix the distillates together again and try to reproduce petroleum, to satisfactorily prove how different the products are from the original substance.

The petroleum upon which Prof. Silliman reported as above did not yield any of the light naphtha to which I have referred, his lightest distillate having a specific gravity of 733, and a boiling point above 400° F., probably because it had been floating on water exposed to the sun, or because it was thick "sur-

face oil." Most of the petroleum, as now obtained from wells in Pennsylvania, yields by the first distillation, either by steam-heat or otherwise, about fifteen per cent of light naphtha, such as is commonly called gasolene, benzine, &c., which is entirely free from any greasy or oily constituent; and this light naphtha, by distillation at comparatively low temperatures as described above, yields about ten per cent of its volume of heavy *paraffine oil*, a new substance produced by heating the vapors above the boiling points of the naphtha, and not simply an educt.

Art. XXVII.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior*; by Raphael Pumpelly.

Believing that we can arrive at a knowledge of the laws which govern the distribution of ore-deposits only through a careful study of the conditions under which ores occur, and especially of the relations which these bear to their mineral associates, the writer hopes through the present paper to increase the interest in active and accurate investigations of this kind among the many competent men scattered through our mining districts. The paper is divided into three parts:

I. The lithology of the rocks in which the deposits of copper are found.

II. The paragenesis, etc., of the mineral associates of copper.

III. Conclusions from the facts observed.

The second part is the result of a careful study of several thousand specimens. No series was admitted to the list when there was any doubt as to the succession, except where the doubt is indicated by an interrogation point.

I. *Lithology of the Trappean Series.*

In the immediate neighborhood of Portage Lake, the strata composing the "Mineral Range" have a uniform trend of N. 35° E., and a nearly equally regular dip of 55°–60° to W.N.W.

The eastern limit of the "range" is formed by a strongly marked and generally vertical plane of demarkation between the highly inclined cupriferous series of rocks and the sandstones which slope gently to the S.E. This sudden break is considered, with probably the best of reasons, by Foster and Whitney, and afterwards by Rivot, to be a longitudinal fracture accompanied by a dislocation of at least several thousand feet. Foster and Whitney looked upon the sandstone as the equivalent of the Potsdam, while the Geologists of the Canadian Survey refer it to the Chazy, and both authorities agree in considering it to be younger than the cupriferous rock, and of the

ame age as the sandstone beds, which are comformably superimposed over the trappean series on the west side of Keweenaw Point.

The trappean series consists of beds of melaphyr, varying in thickness from 20 feet to more than 100 feet, the demarkation being frequently defined by the amygdaloidal or epidotic character of the upper portion of each bed.

At intervals, varying from a few yards to several thousand feet. beds of conglomerate occur intercalated in the series.

This is the general character of the country near Portage Lake for a distance of about three miles, measured from the great line of fracture mentioned above, W.N.W. across the formation.

Still farther W.N.W. the rocks are little known, but seem to consist chiefly of sandstones and conglomerates.

The trappean rocks of Portage Lake occur uniformly in beds varying from a few feet to one hundred feet, or more, in thickness. Frequently an appearance of subordinate bedding is observable, arising perhaps from the existence of joints lying parallel to the plane of stratification, which divide the rock into plates a few inches to several feet thick.

The texture of the many varieties varies from compact and sometimes porphyritic, through fine grained subcrystalline or earthy, to coarse-grained and distinctly crystalline. In individual beds the texture is usually found to undergo a more or less gradual change from compact or granular at the bottom to a vesicular or amygdaloidal condition in the neighborhood of the hanging wall.

Green, of various shades, is the dominating color, and next to this brown and dirty red. Light and dark green, mottled or speckled with brown; dirty brownish-green; reddish-gray; and dark green, almost black, are the usual colors.

In the fresh state these rocks may be easily scratched with a knife, but they are exceedingly tough under the hammer, and the force which crushes a fragment often leaves the powder very firmly compacted.

The fracture is generally uneven, or hackly, to imperfectly conchoidal, but in the freshest, and especially in the compact varieties, it is often highly conchoidal. They have an earthy odor often even without having been breathed upon.

Some varieties yield a thick beard of a magnetic iron ore to the magnet, while others contain very little of this mineral.

The ingredients which are visible under the glass, and which seem to be common to all varieties, are a light *green triclinic feldspar* apparently labradorite and chloritic mineral of different shades of green, while the magnet reveals a very variable percentage of a magnetic iron; and in some of the coarser-

grained varieties small jet black crystals apparently of augite or hornblende are occasionally visible. The accessory minerals observed, many or all of which are probably products of the alteration of the above constituents, are :

A brick-red foliaceous mineral resembling rubellan, occurring as very minute specks in some fine-grained varieties: it lends a soft rusty-brown appearance to the weathered surface, and speckles the interior with red.

Specular-iron in minute flakes, seemingly more frequent in the coarser-grained varieties.

Calcite in seams, and more frequently in grains and amygdules, especially in the amygdaloidal portion of the beds.

Epidote rarely crystallized; most common in the amygdaloidal varieties, but frequently in seams and impregnations, and nearly always associated with quartz which occurs in amygdules and seams, and also as an indurating medium near the hanging wall of many beds.

Prehnite in amygdules and seams, mostly confined to the amygdaloidal portion of the beds.

A chlorite-like mineral, soft, compact, amorphous, greenish-black, sometimes altered to brick-red, occurring in grains from pin-head to walnut size.

A yellowish-green soft earthy mineral, probably a green earth.

Laumontite and leonhardite in seams and amygdules.

Analcite in amygdules.

Orthoclase in small crystals and massive; in amygdaloidal cavities.

Native copper sometimes in fine impregnations in the fine-grained rock, also in thin sheets in jointing cracks, but chiefly in the amygdules, masses, sheets and impregnations which form the metalliferous deposits in the amygdaloids where it is occasionally associated with native silver.

Datholite massive in the amygdaloidal portion of some beds, and also in small aggregations of microscopical crystals in the same positions.

We have fortunately several recent analyses of different and typical varieties of these rocks, made by Mr. Thomas Macfarlane.*

Of one of the coarser-grained varieties which forms very thick beds several hundred feet west of the Quincy "vein." Mr. Macfarlane says: "It is distinctly of a compound nature, but all its constituent minerals are not large enough to be accurately determined. Conspicuous among them is a dark green chloritic mineral, the grains of which vary from the smallest size to one-fourth of an inch in diameter. In the latter case they are irregularly shaped, with rounded angles, but they are never quite round or amygdaloidal [?]. They frequently consist in the center of dark green laminæ. The mineral is very soft, and has a light greenish-gray streak. It fuses readily before the blowpipe to a black magnetic glass, and it would seem to be the preponderating element in the rock. The other constituents are in very fine grains, and consist of a reddish-gray feldspathic mineral, with distinct cleavage planes, and another closely resembling it, in light greenish-gray particles, but whether of a feldspathic, pyroxenic or hornblendic nature could not be determined.

* Canadian Geol. Survey, Report of Progress, 1863–1866, p. 149.

The prevailing color of the rock is dark grayish-green. Hydrochloric acid produces no effervescence with it, even when in the state of fine powder. Its specific gravity is 2·83, and the magnet attracts a very small quantity of magnetite from its powder. The color of the powder when fine is light greenish-gray.

When ignited it loses 3·09 per cent of its weight, and changes to a light brown color. When digested with nitric acid, and afterwards with a weak solution of caustic potash (to remove free silica), it experiences, including the loss by ignition, a loss of 46·36 per cent. This consists of

Silica,	14·73
Alumina,	7·17
Peroxide of iron,	14·87
Lime,	4·47
Magnesia,	2·03
Water,	3·09
	46·36

In the undecomposed residue light-red and dark-colored particles are discernible. On digesting it with hydrochloric acid, and subsequently with a weak solution of potash, it sustains a further loss of 10·6 per cent, which consists of

Silica,	3·48
Alumina,	3·03
Peroxide of iron,	1·98
Lime,	1·76
Magnesia,	·35
	10·60

The undecomposed residue was still found to consist of a light red and a dark-colored constituent. The latter was the heavier, and an approximate separation was accomplished by washing. The dark-colored particles, which could not, however, be freed wholly from the light-colored feldspathic constituent, fused readily to a dark brown glass. To judge from its gravity and fusibility, it would not appear unreasonable to regard it as either pyroxene or hornblende. In quantity it did not, however, exceed one-eighth of the feldspar. The latter fused easily before the blowpipe to a colorless glass, tinging the flame strongly yellow. It would therefore seem to be of the nature of labradorite, although it is only slightly decomposed by hydrochloric acid. Since, according to Girard, neither labradorite, pyroxene nor magnetite, are decomposable by nitric acid, it may reasonably be concluded that the constituents removed by the nitric acid are those of the chloritic mineral. On treating the rock previous to ignition, much of the iron is removed as protoxide.

Although some peroxide is also possibly present, I have calculated the whole of the iron as protoxide, and have moreover, added the difference of the weight between it and the iron estimated as peroxide to the loss sustained by ignition, and put it down as water. In this way the composition of the chloritic mineral, calculated to 100 parts, would be

Silica,	31·78
Alumina,	15·47
Protoxide of iron,	28·87
Lime,	9·64
Magnesia,	4·37
Water,	9·87
	100·00

In these figures the quantity of iron is much greater and that of magnesia much less than in ordinary chlorite. In its composition, and in being easily decomposed by acids, the mineral most closely resembles the ferruginous chlorite of Delesse, (the delessite of Naumann) but differs from it in containing a considerable amount of lime, and in being readily fused before the blowpipe. Assuming, nevertheless, that the chloritic constituent is delessite, and that one-half of the iron removed by hydrochloric acid belongs to the magnetite, then the rock would be composed mineralogically of

Delessite,	46·36
Labradorite,	47·43
Pyroxene or hornblende,	5·26
Magnetite,	0·95
	100·00

By the same method of analysis, Mr. Macfarlane found the rock underlying the copper-bearing bed of the Quincy mine to consist of

Delessite in amygdules and grains,	38·00
Labradorite,	62·00
	100·00

This rock is distinctly amygdaloidal. "The matrix is fine grained, but it is crystalline, and is seen to consist of different constituents. Its color is dark reddish-gray." Its cavities, rarely the size of a pea, are filled with what seems to be the same chloritic mineral which occurs as a constituent of the rock above described.

Mr. Macfarlane also examined the rock which overlies the Albany and Boston conglomerate at the Albany and Boston mine. "It is a fine grained mixture of dark green delessite, greenish-gray feldspar, and reddish-brown mica, some of the

ninæ of the latter showing ruby-red reflections. Its specific avity is 2·81, and the smallest trace only of its powder is ;racted by the magnet." He considers the mineralogical comsition of this rock to be

Delessite,	40·00
Mica,	20·00
Labradorite,	40·00
	100·00

The rocks, to which the above given analyses refer, are repreıtatives of the three predominating types of the trap of ›rtage Lake. Mr. Macfarlane's results agree very closely th my own observations on several hundred specimens, aided the blowpipe, and examination of external characteristics.

Everything goes to show that the normal, essential constients of these rocks are in their present condition a triclinic dspar, probably labradorite, and a ferruginous chlorite closely ied to delessite. This composition places these rocks among e typical melaphyrs, the greater specific gravity of the Portage .ke varieties being accounted for by the fact that the sp. gr. delessite is 2·89, while that of ordinary chlorite ranges from 35 to 2·78.

Although the name melaphyr is an unfortunate one, having en first used to designate an entirely different rock, and havg been successively applied to others of very various characs, it is now the only distinctive name for the class we have der consideration. All the trap rocks and associated amygloids of Portage Lake are varieties of melaphyr.

But I do not doubt that any one who will carefully study melaphyrs of Portage Lake, and compare them with their ıivalents in Keweenaw county, will feel convinced that the ·laphyr owes its distinctive character to a process of meta›rphism, in which the chlorite resulted, largely or wholly, m the alteration of hornblende or pyroxene. In the more tinctly crystallized traps of Keweenaw county, the pseudo›rphic occurrence of chlorite after the hornblende or pyroxene ıstituent of the trap, may be traced through all the stages to omplete replacement of the latter by chlorite.

The principal varieties of melaphyr on Portage Lake are

1. *Coarse-grained;* in which the crystals of feldspar and ıins of delessite are more or less distinct. The color is ›enish-gray. It contains generally grains of magnetite and all tabular crystals of specular iron.

2. *Fine-grained;* the constituents, light-green or reddish trinic feldspar and dark-green delessite, are sometimes distinishable, but more generally they are not so. The usual color grayish-green, but it sometimes is speckled with brown

through the presence of small flakes of rubellan; or mixed green and brown, from the oxide of iron produced in the decomposition of some of the constituents. As a rule, the greater the amount of rubellan the less there seems to be of magnetite. In some instances, especially in some of the beds east of the Isle Royale copper-bearing bed, the rock is fine grained and sub-crystralline, brilliant black-green, sometimes purplish; slightly shimmering; easily scratched with the knife; contains considerable magnetite, small pieces of rock adhering to the magnet. It weathers rusty gray.

3. *Melaphyr-porphyry;* dark-green, often nearly black; compact with perfect conchoidal fracture; very hard; contains minute crystals of triclinic feldspar.

Amygdaloids.

The amygdaloids are merely varieties of the melaphyr. On Portage Lake they always form the upper or hanging-wall portion of beds of trap, into which they pass by a more or less gradual transition.

It is rare that one finds a bed of trap which does not contain here and there scattered segregations of secondary minerals, especially delessite, but often calcite, laumontite, quartz or chalcedony, prehnite, occupying cavities which are often well defined and spherical or ovoidal, but sometimes wholly irregular in shape, and without definite walls. These enclosures usually become more frequent in ascending from the foot-wall of a bed toward the hanging wall. The plane of demarkation between the amygdaloidal upper portion of a bed and the overlying rock is always well defined. Where they are sufficiently numerous to impress a distinctive character upon the rock, while at the same time the matrix retains the essential features, in regard to color and texture of the parent trap, I have designated the variety

Amygdaloidal Melaphyr.

All the varieties of melaphyr on Portage Lake are subject to this modification, but there is a considerable variation among different beds in regard to the nature of the minerals in the amygdaloidal cavities. In all the varieties, amygdules of delessite, or calcite or quartz coated with delessite, or again spots of epidote, occur here and there in the body of the rock. In some beds the rock is characterized throughout by the presence of laumonite in small amygdules and minute seams.

In the belt occupying 1,000 feet or more on either side of the Isle Royale copper-bearing bed, many of the beds assume towards the top amygdules of delessite and of a green flinty mineral, resembling chrysoprase, coated with delessite. These are gradually succeeded nearer the top by ovoidal, lenticular or irregular amygdules, from the size of a bean to several inches

ı diameter of prehnite, greenish-white, or tinged with pink enerally amorphous, but often with a radiating structure, and ›metimes slightly impregnated with native copper.

The portion of the bed nearest the hanging wall is often ighly amygdaloidal, while the matrix has at the same time a ifferent degree of hardness, texture and color, and often a ifferent mineralogical constitution from the parent trap. These arieties form the

Amygdaloids proper.

The amygdaloids are the most highly altered form of the ıelaphyr, and present themselves under a variety of characters ı different beds and in different parts of the same bed. The olors of the matrix are different shades of brown or red, and f green, or of these mixed; its texture varies from fine grained r sometimes subcrystalline to compact; and its hardness ranges :om that of limestone to that of quartz.

Two quite different kinds of amygdaloid occur on Portage ›ake, both separately, and intimately associated in the same ed, and are easily distinguished by their different colors, the ne being brown and the other green.

The brown, which exhibits the amygdaloidal character in its ighest development, has a chocolate-brown to dirty red matrix, 'hich generally is easily scratched with the knife, but is some-mes indurated and hard; it has a fine grained to subcrystalline ›xture, and now and then contains minute reddish crystals of ›ldspar, and fuses easily to a dark-green and somewhat mag-etic glass.

The amygdules in this variety are more generally spherical, ut often somewhat irregular and connected, and more rarely ›ng-cylindrical, and then usually perpendicular to the plane of edding. The contents of these cavities, for they are very arely empty, are laumontite, leonhardite, calcite, quartz, a soft reen mineral, apparently green-earth, delessite (more rarely), ative copper, epidote, prehnite, analcite, orthoclase. In places ne, in others another of these, predominates; generally several re associated.

The green variety is a very fine grained to compact light rayish-green rock. It is generally very hard, striking fire nder the steel. Its constituents are very largely free silica, nd a green mineral which has been generally taken for epidote, ›ut which is so minutely disseminated as to render it difficult f determination. Small pieces of the rock fuse easily on the dges to a dark enamel which gelatinizes with acids. These ›eds are called epidote "veins," and they are probably in many ıstances, at least, an intimate mixture of quartz and epidote, hough in otherwise nearly similar beds, the green mineral ; soft, and is probably either a green-earth or a chlorite.

The cavities in this variety are often less regularly defined in shape than in the brown amygdaloid. The enclosed minerals are quartz, epidote, calcite, delessite, prehnite, laumonite, green-earth, analcite, native copper, orthoclase. These two varieties of amygdaloids often occur together without any well defined lines of separation, the bed being made up of irregular masses of the two rocks. In places, however, the brown amygdaloid forms a band one to two feet thick on the hanging wall, with a rather abrupt transition into the green amygdaloid underlying it; I have never observed the reverse.

Some beds have an exceedingly mixed character; the amygdaloidal portions are associated with massive segregations of calcite, quartz and epidote, and are traversed by seams and irregular veins of these minerals; this structure is especially noticeable in the beds worked for copper. A somewhat similar structure occurs in other beds on a smaller scale, giving to them a brecciated or even a conglomerate-like appearance, which seems, however, to be due to purely metamorphic action; the best example of this is in the "Ancient pit" bed on the Shelden and Columbian property.

Conglomerates.

The conglomerates of Portage Lake differ from each other but little, if at all, in lithological characteristics. The pebbles vary from the size of a pea to one foot or more in diameter, being coarser in some beds than in others. The different beds vary in thickness from mere seams to several hundred feet, and the same bed often varies greatly in width.

The pebbles, in most of the beds on Portage Lake, consists almost exclusively of varieties of non-quartziferous felsitic porphyry; two kinds predominate; one of these has a chocolate-brown to liver-brown, subcrystalline to compact, almost vitreous, matrix containing very scattered minute crystals of triclinic feldspar of the same color as the base. The other and rarer variety, also non-quartziferous, has a chocolate-brown, compact to minutely crystalline matrix, in which lie crystals, $\frac{1}{8}$–$\frac{1}{2}$ inch long, of a flesh-colored triclinic feldspar.

In some beds there appear pebbles of a flesh-red rock, composed almost entirely of granular feldspar, containing small specks of a black undetermined mineral. In some instances the feldspar is wholly triclinic, in others the twin-striation is frequently absent. This variety of pebble is altogether absent in some beds, at least where they are opened, while in others they predominate, as in the Albany and Boston Conglomerate. Pebbles of compact melaphyr and of melaphyr amygdaloid also occur, but are quite subordinate in number to those already enumerated.

he normal form of cement is a fine grained sandstone, com-
d apparently of the same material as the pebbles. Often
:ement is very subordinate in volume, the pebbles touching
other. Frequently, however, the reverse is the case, and
ı the sandstone forms layers from less than an inch to many
in thickness.

he original character of the cement is often entirely lost; the
stices between the pebbles are sometimes, though rarely,
ty; in places the sand is associated with oxide of iron, chlo-
a white talc-like mineral, carbonate of lime, or it is entirely
ıced by calcite, chlorite, epidote or even native copper.

is a remarkable fact that while all the conglomerate beds
Portage Lake are free from pebbles of quartz-porphyry,
ɜ in the neighborhood of Calumet are characterized by
ɔles rich in grains of quartz. This abrupt change takes
ɜ about six miles N.E. from the lake.

ifferent horizons of the Portage Lake series of rocks are
ced by certain distinguishing lithological characteristics,
:h, without in any instance being peculiar to a given
zon, still serve to mark decidedly those parts of the series
re they are, respectively, most frequent.

ıus, to begin toward the eastern part of the field, from the
hborhood of "Mabbs' vein" to within, say, 1,000 feet E.
ıe Isle Royale "vein," there is a tendency, among the dif-
ıt traps, to a compact or fine grained texture with a dark-
n, almost black, color, sometimes slightly mottled, especially
he weathered surface. The fracture is brilliant, and the
contains enough magnetite to cause small bits of the rock
ıhere to the magnet.

rom this region till 1,500 feet or more west of the Isle
ale copper-bearing bed, the upper portion of very many of
beds have the amygdaloidal cavities filled with a light-
nish white or pale pink prehnite, which sometimes, for a
h of 2 to 6 feet, form from 10 to 40 per cent of the rock,
lend it a very characteristic spotted appearance.

uring the next 2,000 feet or more, the traps have frequent
ıs 3 to 20 inches thick, consisting of distinctly individual-
triclinic feldspar, delessite, prehnite and specular iron; these
r both parallel to the plane of bedding and oblique to it. The
s through a portion of this distance are frequently impreg-
d with epidote, as is also the cement of the conglomerate beds.
ı the "Dacotah" property we come to a belt of the forma-
in which many beds have a tendency to a coarse-grained,
:alline texture, and in some the character is highly de-
ped, giving the rock, at a distance, almost the appearance
chloritic granite. Still farther west, on the "Southside"
erty, the brown amygdaloids often present a scoriaceous
arance which is quite characteristic.

Some, at least, of these features, are traceable for miles in the longitudinal extension of the zones in which they occur. Thus the prehnitic amygdaloid of the Isle Royale series, is found in the N.E. extension of this zone, near where the road to Eagle river crosses the line between Townships 55 and 56 N., or about 7 miles from Portage Lake.

The coarse-grained melaphyr of the "Dacotah," is found extensively developed in the extension of the same zone on the South-Pewabic, Quincy and St. Mary's properties. The brown amygdaloids of the "Southside" reappear with their peculiar scoriacious structure in the South-Pewabic and Hancock beds, and in the trenches on the St. Mary's, and have been considered the equivalents of the "Ash-bed" rocks of Keweenaw county, which they resemble.

[To be continued.]

ART. XXVIII.—*Observations on the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D., President of the Stevens Institute of Technology.

As the result of a series of experiments to be presently described, I have come to the curious conclusion that all the familiar fluorescent solutions, such as the tincture of turmeric, of agaric, of chlorophyl, and the solution of nitrate of uranium, emit light of the same color by fluorescence, namely, blue identical with that developed by acid salts of quinine. This blue, however, as is well known in the case of quinine, is not of a single tint or refrangibility, but yields a continuous spectrum, in which the more refrangible rays predominate.

My attention was first drawn to the subject by observing that a specimen of mixed asphalt, which is here largely used in the preparation of pavements, yielded a light-yellow solution with alcohol, which fluoresced blue, and an orange solution with turpentine, which fluoresced green. It at once occurred to me that the green color was simply due to the absorptive action of the colored solution, and not to the development of green rays. Examined with the spectroscope, the seemingly green fluorescence showed no increase in the green or yellow part of the spectrum, as compared with the blue fluorescence, but only an absorption of the red and violet ends. When, however, a piece of fluorescing canary glass or solid nitrate of uranium was examined, the green light was (as is well known) largely augmented. I also found that when, by filtration through animal charcoal, the solution in turpentine was reduced in color, the green tint of the fluorescence disappeared in a corresponding degree. This alone would, however, have proved nothing, as a green

fluorescing matter might have been absorbed by the charcoal, but in connection with the spectroscopic result it was of interest.

I next took up for examination the tincture of turmeric. This is set down in standard works, such as those of Du Moncel and Becquerel, as fluorescing red. This solution, when concentrated, has a rich orange-red color, and the jacket of a Geissler tube being filled with it, all the light reaching the eye, from the electric discharge within, is of a deep orange or red color. If, however, the solution is simply diluted until its color is reduced to a rich yellow, the fluorescence appears green. The same result follows from filtration through bone black, with a marked increase in the amount of fluorescence visible, as the light-absorbing coloring matter is removed. By continuing the decoloration until the liquid is colorless or of a very light tint, its fluorescence is distinctly blue.

The results with the spectroscope when it was applied to this substance, were the same as with the solution of asphalt. Such also is the case with tinctures of chlorophyl, which, when fresh and green, gives apparently a green light, and, when old and brown, a gray color.

Finally, I took up the nitrate of uranium, about which such contradictory statements have been published. This salt in its solid state gives a brilliant green fluorescence, whose spectrum is figured by Becquerel, and abounds in green rays; but in solution it gives a very feeble fluorescence, far inferior to that of turmeric, and of no more green tint than would be due to its yellow color. So in fact says also the spectroscope.

From these results it would seem that the molecules of fluorescent bodies *in solution* are not capable of restricting their vibrations to limited ranges, but move at rates corresponding with all refrangibilities, having simply an excess of the higher ones, though the same substances in the solid state may act quite differently, as in the case of nitrate of uranium, and possibly the fluorescent material in the asphalt, which may be related to the solid hydro-carbon fluorescing green, which Becquerel mentions (*La Luminere*, tome i, p. 382).

In this general connection let me mention that I have observed that while the acid salts of quinine generally are fluorescent, the chloride is not, and that hydrochloric acid will decompose the acid sulphate so as to destroy its fluorescence.

There are several other points in connection with this and the foregoing subject, which I must leave for a subsequent discussion.

July, 1871.

P. S.—Aug. 1st. I have just obtained results with turmeric, which seem to indicate that its fluorescence is due to the presence of a substance not yet observed, soluble in water, and without any color.

ART. XXIX.—*Mineralogical and Chemical Composition of the Meteoric Stone that fell near Searsmont, Maine, May* 21, 1871; by J. LAWRENCE SMITH.

IMMEDIATELY after the fall of this meteoric stone a portion of it was placed in my hands for examination. The circumstances accompanying its fall, as well as its physical characters, have been described in the last number of this Journal by Prof. Shepard (p. 133).

It resembles very closely the Mauerkirchen stone that fell in 1768, the crust of the specimens corresponding quite closely to that in thickness and appearance; the Mauerkirchen stone, however, has not well-marked globules like that of Searsmont; in this respect it corresponds more nearly with the Aussun, as already stated by Prof. Shepard.

The specific gravity of the specimen examined was 3·701.

The nickeliferous iron and stony matter were separated mechanically for analysis. One hundred parts of the meteorite gave

Stony matter (including a little sulphuret of iron)	85·38
Nickeliferous iron	14·62

The iron afforded:

Iron	90·02
Nickel	9·05
Cobalt	·43

Phosphorus and copper were not estimated. The stony part, treated with a mixture of hydrochloric and nitric acids, gave:

Soluble in the acid	52·3
Insoluble " "	47·7

The soluble portion afforded:

Silica	40·61
Protoxide of iron	19·21
Magnesia	36·34
Sulphuret of iron	3·06

Leaving out the sulphuret, which is obviously only a mechanical mixture, this soluble part is evidently an olivine,—which is almost invariably the case with soluble portions of meteoric stones.

The insoluble part was composed as follows:

Silica	56·25
Protoxide of iron	13·02
Alumina	2·01
Magnesia	24·14
Alkalies, NaO, KO with trace of LiO	2·10
Chrome iron, small black specks	not estimated

ıe above analyses give for the composition of the stone:

Nickeliferous iron	14·63
Magnetic pyrites	3·06
Olivine	43·04
Bronzite, a hornblende, with a little albite or orthoclase, and chrome iron	39·27

ı the bronzite there may also be enstatite, which would be ›unded with the former, if existing in the stone.

XXX.—*Discovery of a new Planet;* by Prof. C. H. F. :TERS. From a letter to one of the editors, dated Litchfield ›servatory of Hamilton College, Clinton, Oneida Co., N. Y., .ly 27, 1871.

small planet, the 114th of the group of asteroids, was dis- :ed here in the night from the 23d to the 24th inst., and the ving accurate positions hitherto have been obtained of it:

.	Ham.Coll. m.t.	App. α (114)	App. δ (114)	
	h m s	h m s	° ′ ″	
4.	15 14 45	21 43 27·35	−10 12 16·8	(by 6 comp'sons with Schj. 8925)
6.	12 18 4	21 42 8·35	−10 20 26·0	(by 12 " " W. 21 h. 954)

:nce follow the daily motions resp. $-42^s \cdot 3$ and $-4' \, 21''$. magnitude of the planet was estimated this morning in a fine sky to be 12·3. As it is still about a month yet until sition, it will become considerably brighter. The planet *ına* (19) runs nearly parallel to it, distant only one degree, ;, however, of the 9th magnitude.

XXXI.—*On a new Planet;* by JAMES C. WATSON. From etter to one of the editors, dated Observatory, Ann Arbor, ıgust 7, 1871.

ıoticed last night a star of the tenth magnitude near Weisse , 462, and a single comparison gave the following place:

	Ann Arbor M. T.	α	δ
71,	Aug 6. $10^h\ 40^m$	$21^h\ 21^m\ 9^s \cdot 90$	$-12^\circ\ 30' \cdot 1$

subsequent comparison showed that it had moved, and the ving observations were made:

	Ann Arbor M. T.	(115) α	(115) δ	Comp.
Aug. 6.	$12^h\ 24^m\ 4^s \cdot 6$	$21^h\ 21^m\ 4^s \cdot 64$	$-12^\circ\ 30'\ 6'' \cdot 3$	4
6.	14 3 36·1	21 20 59·77	12 29 57·6	7
6.	14 59 1·1	21 20 57·19	−12 29 53·5	5

Daily motion, $\Delta\alpha = -69^s \cdot 5$ $\Delta\delta = +1'\ 59''$.

ıe planet shines like a star of the tenth magnitude.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the existence and formation of Salts of Nitrous Oxide.* —The reduction of an alkaline nitrate to nitrite by means of sodium was observed by Schönbein, but the further action of the metal upon the nitrite itself has not hitherto been studied. Divers finds that an amalgam of sodium reduces the nitrite to a salt of nitrous oxide, the successive stages of the reaction being represented by the equations—

$$\mathrm{Na\,N\Theta_3 + Na_2 = Na\,N\Theta_2 + Na_2\Theta},$$
$$\mathrm{Na\,N\Theta_2 + Na_2 = Na\,N\Theta + Na_2\Theta},$$

So that four atoms of sodium are required for the reduction of one molecule of the nitrate. The reduction of the nitrite is accompanied by the evolution of pure nitrous oxide, and the author explains this by the mutual reaction of two molecules of the new salt according to the equation—

$$\mathrm{Na\,N\Theta + Na\,N\Theta = N_2\Theta + Na_2\Theta}.$$

After neutralization by acetic acid, the alkaline liquid gives a yellow pulverulent precipitate with argentic nitrate. This precipitate has the formula, $\mathrm{AgN\Theta}$: it is almost as insoluble as argentic chloride, and may be washed with hot water without change. Light does not decompose this salt; ammonia and ammonic carbonate dissolve it; and acetic acid precipitates it from the solution unchanged. Dilute nitric and sulphuric acids dissolve the salt without immediate decomposition; alkalies precipitate the salt unchanged. It is instantly oxidized by concentrated nitric acid, with production of copious red fumes. Soluble chlorides and sulphuric acid also decompose it. When heated to redness, pure silver finally remains, nitric oxide, metallic silver and a little argentic nitrate being at first formed. When the alkaline liquid containing the sodic salt is neutralized with dilute nitric acid, it gives precipitates with various other metallic salts. The author promises a farther investigation of this very interesting subject, and meantime purposes to call the new acid, $\mathrm{N\Theta H}$, either *hypo-nitrous* or *hydro-nitroxylic* acid.—*Proc. Royal Society*, xix, p. 425. W. G.

2. *On a remarkable group of Mercurial Colloids.*—By the action of mercuric chloride upon an alkaline solution of acetone, and submission of the mixture to dialysis, Reynolds has obtained a compound of mercuric oxide with acetone, having the formula $\{\mathrm{C\Theta\,(CH_3)_2}\}_2\mathrm{Hg_3\Theta_3}$. This substance forms the type of a new and curious group of organic bodies distinguished by their essential colloid or gelatinous character. A solution of the acetone compound, containing five per cent., remains fluid, if pure, for twelve or fourteen days, and then sets to a firm jelly. The same result is produced in a few seconds by the addition of very minute traces of various acids, alkalies and salts. Even some insoluble

wders, like calcic carbonate and alumina induce pectization. evation of temperature quickly produces the same effect: thus, th a five per cent solution, a firm jelly is produced by heating 50° C. The solution, when evaporated to dryness, yields a sinoid mass of the anhydrous compound. By the action of cohol upon the one per cent solution, the author obtained what aham termed the *alcosol* of the new body. This gelatinized by ıg boiling to form the *alcogel.* Acetone-mercuric oxide appears be an extremely feeble but well marked tetrabasic acid. The y salts are resinoid bodies very difficult to obtain in a state of rfect purity. Several other ketones of the fatty acid series are pable of forming compounds analogous to that described above. ıe higher compounds are, however, insoluble in water, so that it difficult to obtain their colloidal hydrates or hydrosols. The hydrous butyrone compound has the formula $\{ЄΘ(ЄH_3)_2\}$ $g_3\,Θ_3$. Elthylic aldehyde forms with mercuric oxide a white n-crystalline compound, but does not give a colloid liquid.—*roc. Royal Society*, xix, p. 431. W. G.

3. *On a new Synthesis of Acids.*—Von Richter has given a w method of forming organic acids likely to be fertile in inter-ting results. This method consists in acting upon $NΘ_2$ com-unds with potassic cyanide so as to produce the corresponding anides, which are then to be boiled with an alcoholic solution of ustic potash as long as ammonia is evolved. The liquid then ntains an organic salt of potassium, from which the acid may sily be obtained. Thus, in the case of bromo-nitrobenzol we ıve

$$Є_6H_4Br\,NΘ_2+KЄN=Є_6H_4Єy\,Br+KNΘ_2,$$

is being the only part of the process which is really new. hen treated in this manner, ortho-bromonitrobenzol (fusing point 5° C.), yields ortho-bromobenzoic acid, $oЄ_7H_5B_2Θ_2$. Meta-omonitrobenzol (fusing point 56° C.), in like manner yields meta-omobenzoic acid, $mЄ_7H_5B_2Θ_2$, while para-bromonitrobenzol ısing point 37° C.) does not react with potassic cyanide. The rresponding chloronitrobenzols were also studied. Orthochloro-trobenzol (fusing point 84° C.) yields orthochlorobenzoic acid, $Є_6H_8Br\,Θ_2$. On the other hand, a chloronitrobenzol (fusing at ° C.) gave chlorosalylic acid, which, when fused with potash, elded salicylic acid.—*Berichte der Deutschen Chem. Gesell.*, iv, 457. W. G.

4. *On Gallein.*—When pyrogallic acid is fused with phthalic id, hydrous, or better anhydrous, the fused mass dissolved in ater yields a new coloring matter in small granular crystals, hich Baeyer terms gallein. The new substance is brown-red by flected and blue by transmitted light, and when obtained by aporating its solution to dryness, exhibits a peculiar yellow etallic lustre. Water dissolves it with difficulty, giving a red, cohol easily, giving a dark red, solution. Caustic potash dis-lves it with a magnificent blue color, which after some time

becomes dirty; ammonia gives a violet solution. The author remarks that gallein closely resembles hæmatein, which by fusion with caustic potash yields pyrogallic acid. In like manner, as hæmatein, with reducing agents, yields hæmatoxylin, which may again be oxidized to hæmatin, so gallein may be reduced to gallin, a beautifully crystallized substance, which, when moistened with ammonia, again yields gallein. Stuffs mordanted with alumina or ferric oxide are dyed red by gallein, the color being intermediate between that of logwood and brazilwood. The constitution of gallein appears to be represented by the formula $\text{C}_{18}\text{H}_{17}\text{O}_7$: it appears clearly to belong to the family of the coloring matters of logwood and brazilwood, and is therefore the first artificial dyestuff of this group. Gallin has probably the formula $\text{C}_{18}\text{H}_{16}\text{O}_6$: it crystallizes in beautiful lustrous rhombohedrons and prisms. It dyes mordanted stuffs like gallein. When gallein is heated with 20 parts of concentrated sulphuric acid to 200° C., a new substance is formed, which, when purified, presents a bluish-black mass, and which Baeyer terms cœrulein. This body dissolves in hot anilin with a magnificent indigo-blue color. The solution, after adding a little acetic acid, dyes wool indigo-blue. The formula of cœrulein is $\text{C}_{18}\text{H}_{10}\text{O}_6$. By reduction, it passes into cœrulin, which dissolves in ether with a yellow color, the solution exhibiting a beautiful green fluorescence. Cœrulin appears also to be formed directly by the action of sulphuric acid upon gallin. Cœrulein dissolves in alkalies with a green color, and gives a green lake with the earths. Stuffs mordanted with alumina are dyed green; those with ferric oxide brown; the colors appear to be as fast as those of madder. The author points out its resemblance to the Lo Kao of the Chinese. Phthalic acid heated with resorcin yields two coloring matters, fluorescein and fluorescin. The former dyes silk and wool of a beautiful yellow without mordants, and exhibits in solution a magnificent green fluorescence. The author promises a further investigation of this interesting and possibly important subject.—*Berichte der Deutschen Chem. Gesell.*, iv, p. 457 and p. 555.

W. G.

5. *Decomposition of Chromite;* by R. HITCHCOCK.—Chromite is one of the most difficult minerals to decompose, and, although there have been many processes given to effect its analysis, they have generally accomplished the purpose rather unsatisfactorily.

The process given by F. W. Clarke, and published some time ago in this Journal, wherein potassic di-sulphate and cryolite are used, undoubtedly effects the decomposition of the ore; but the amount of sulphate and cryolite required is so great, and the chromium dissolves in such a form, that I have never been able to obtain tolerable results by this method.

A number of experiments have convinced me that the process given below is equal, if not superior, to any I have yet tried, both in accuracy as well as rapidity of manipulation. The process is this: place about 0·3 grm. of the mineral in a capacious platinum

rucible, add a piece of ammonic-fluoride about the size of a pea; moisten the whole with a few drops of concentrated sulphuric acid, heat gently until the free acid is expelled. Add now a small piece of potassic disulphate, and bring the mass to a tranquil fusion, maintaining it so for a few moments. Allow to cool, and add a mixture of four parts of potassic and sodic carbonates with one of nitre; fuse gradually, and when the mass becomes tranquil maintain it fused for about fifteen minutes. If cooled by placing the crucible on a plate of cold iron, the mass is readily detached. It is then dissolved in boiling water, and the solution filtered from the residue of iron, which still retains some chromium, and must be again fused with the mixture of carbonates and nitre above given. Sometimes this second fusion requires to be repeated, but for practical purposes this is unnecessary if the previous operations have been well conducted. The bulk of all three filtrates need not be over 200 c.c. The chromium may be estimated by cautiously acidifying the solution, reducing the chromium to the state of sesquioxide by means of sulphurous acid solution, and precipitating by ammonic hydrate. If the Bunsen method of filtration is used, the large amount of alkali present does not materially affect the results. If manganese is present in the ore, it may be determined from the alkaline solution. One advantage of this method is, that there is no troublesome evaporation required to separate silicon.

Results of parallel analyses:

1.	Chromite = ·2888	per cent Cr_2O_3	50·450
2.	" ·2868	per cent Cr_2O_3	50·627
			·177

I am confident that with more experience still better results may be obtained.

II. Geology and Natural History.

1. *Address to the American Association for the Advancement of Science*, by Thomas Sterry Hunt, LL.D., on retiring from the office of President of the Association, Indianapolis, Aug. 16, 1871. 32 pp. 8vo.—Dr. Hunt takes for the themes of his address, first the geology of the Appalachians, especially the history of researches and views with regard to the New England section of this chain; and secondly, the origin and nature of the changes which crystalline rocks have undergone; setting forth under each the labors of others in connection with his own, and also the conclusions to which he has been led. He first divides the crystalline rocks of the chain into three series, draws out the distinctive lithological characteristics of each, and maintains that they belong to different geological eras. They are—

I. The *Adirondack or Laurentide Series*, which is marked by "firm granitic gneisses, often very coarse-grained, and generally reddish or grayish in color," often hornblendic, and little micaceous, and including great beds of magnetic iron ore, and much graphite; but without argillites, or slates containing staurolite, andalusite or cyanite.

II. The *Green Mountain Series*, characterized, he observes, by a fine-grained petrosilex or eurite, which often passes into a true gneiss that is ordinarily more micaceous than the typical Laurentian gneiss, and not very coarse-grained, the color grayish or pale greenish instead of reddish; also by diorites, epidotic and chloritic rocks more or less schistose, steatite, dark colored serpentine, with some slaty hematite or magnetite; also micaceous quartzites and argillites, often unctuous in feel, though not magnesian. Chrome, titanium, nickel, copper, antimony and gold are frequently met with in this series.

III. The *White Mountain Series*, characterized by well-defined mica schists and interstratified micaceous gneisses, the latter often light-colored, fine or coarse-grained and sometimes porphyritic; the mica schists richer in mica than those of the Green Mountain series; also micaceous quartzite; hornblendic gneisses and schists; also crystalline limestones accompanied by pyroxene, garnet, idocrase, sphene and graphite, like the limestones of the Laurentian, but often intimately associated with highly micaceous schists containing staurolite, andalusite, cyanite and garnet, and sometimes highly plumbaginous. The rocks are intersected by granite veins containing tourmaline, beryl, lepidolite, and occasionally tinstone and columbite, only the first of these minerals occurring, as far as known, in the Laurentian gneisses.

After thus dividing lithologically the rocks into these three series, Dr. Hunt endeavors to trace them southwestward along the Appalachians, through the descriptions of other geologists; and later in his address, he uses the same lithological evidence to divide off the crystalline rocks of other continents. The evidence as to the different ages of the Green Mountain and White Mountain series is not touched upon; neither is the value of lithological characters among crystalline rocks in the determination of geological equivalency discussed, beyond making an affirmation on the point, and citing the opinions of one or two authors.

The history of the discoveries and views of geologists pertaining to the so-called Taconic rocks, and the formations associated with them in the Green Mountain series, is next ably presented, the Primordial character of part of them recognized, as determined by Billings and Barande, and the later Lower Silurian character of some other portions. But with regard to the crystalline rocks, constituting his "Green Mountain Series," he says:—"Although I have, in common with most other American geologists, maintained that the crystalline rocks of the Green Mountain and White Mountain series are altered paleozoic sediments, I find, on a careful examination of the evidence, no satisfactory proof of such an age and origin, but an array of facts which appear to me incompatible with the hitherto received view, and lead me to conclude that the whole of our crystalline schists of eastern North America are not only pre-Silurian but pre-Cambrian in age"—a conclusion which all will say should be thoroughly tested by reference to stratigraphical facts before it is generally accepted.

The "Origin of Crystalline Rocks," the subject of the second rt of the address, is next discussed. Facts are brought to ar upon it from various sources, many of them the result of Dr. unt's own careful chemical investigations. He brings out, and, course, advocates his own peculiar views on pseudomorphism d metamorphism,—views which have been presented by him in is Journal, and need not be here repeated. He closes with a view of recent observations, and mainly his own, connected with e origin of the minerals constituting and associated with the ecimens of Eozoon; and finally treats briefly of the origin of nestones and dolomites, making some great formations of them chemical origin.

The conclusions throughout Dr. Hunt's address are open to ubts and objections; but their discussion would require as many ges as he has found necessary for presenting them.

2. *The distribution of Maritime Plants in North America a oof of Oceanic Submergence in the Champlain Period* [that llowing the Glacial]; by C. H. HITCHCOCK, of Hanover, N. H. -In this paper, Prof. Hitchcock has collected together the facts ith regard to the distribution over North America of plants that operly belong to sea-shores, and draws from them the conclun expressed in the title of his paper above given. The arguent is an important one. But still it may be queried, considerg the much greater number of shells and of other kinds of arine *animal* life that must have existed in those Champlain as, whether their *absence* from the same regions all over the Unid States, beyond a height of 300 to 600 feet above tide-level in e more northeastern portions, is not better proof that the sea d *not* cover the continent in the Champlain era. It is hard to lieve that there could have been thousands of miles of seaaches across the continent, or hundreds of thousands of square iles of sea-bottom, in an era of abundant marine life, and yet l—with the exceptions along the borders of the Atlantic, along e River (then Gulf of) St. Lawrence, and on Lake Champlain hen an arm of that Gulf)—without any traces of marine animal e.

If the depth over the continent were 5,000 feet or more, as some ve supposed, there would have been sea-bottom everywhere, if no a-beaches; and if but 500 to 1,000 feet, as others have inferred, a-beaches would have been almost interminable as well as seattoms. The latter depth (or but 600 feet in the St. Lawrence gion) has been thought sufficient to turn a part of the Labrador rrent in full flow over the continent, thence to discharge itself the Mississippi valley into the Mexican Gulf, and hence sufficient so to transport southward icebergs that might be in the way.

But oceanic currents, although strongest toward the sides of an ean, where the depth is diminishing landward, are extremely eble over ordinary off-shore soundings; and many facts prove at the waters of the continent, in the supposed case, would be but e waters of a great interior sea, having only the very feeble

movement that might come from the tides setting in by the south and the northeast, so that the necessities of the iceberg theory would not be met. Icebergs and vast fields of floating ice over the interior of the continent were probably among the phenomena of the closing glacial era, during the opening Champlain period; but the waters bearing them must have been fresh waters—viz., those of the much expanded Great Lakes, and those of the flood (first appealed to in this connection by Prof. Hilgard) which proceeded from the melting continental glacier over the vast funnel-shaped Mississippi valley reaching from the Appalachians on the east to the far distant Rocky Mountains on the west.

In a geological paper on the New Haven region (Connecticut), recently published by the writer, it is stated that the Champlain beds of sand and gravel which underlie the plain about the bay, show, by the character of the stratification, that they were deposited by the inflowing tidal waves; but over a region where the Quinnipiac valley opens out upon the plain, the evidence of tidal deposition stops abruptly at a level twenty feet from the top, and these upper twenty feet nearly to the top bear unquestionable evidence of deposition by the *outflowing flooded river.* This part of the continent, therefore, was certainly not submerged in a deep or shallow ocean during the Champlain era. J. D. D.

3. *Some of the Results of the Latest Researches in the Waters of the Atlantic and Mediterranean.*—These results, as set forth in a lecture by Dr. Wm. B. Carpenter, before the Royal Institution, are briefly as follows:

(1.) The waters of the Atlantic between Falmouth and Lisbon are most salt and dense at the surface, as first observed by Forchhammer. The specific gravity ranged from 1·0269 to 1·0265, the maximum at surface, the minimum at bottom. The amount of chlorine in grams per 1000 cubic centimeters of water (determined by volumetric analysis) averaged at surface 19·94, at bottom 19·75, intermediate region 19·85. The maximum at surface was 20·19. In waters taken on the same vertical line the chlorine was at surface 20·013, at 10 to 50 fathoms 19·909, at 100 f. 19·805. This excess of saltness at surface is attributed to evaporation. But the consequent greater density is stated to be neutralized by the effects of colder temperature below.

(2.) The saltness in the Mediterranean is greatest below the surface. In the shallower parts, it is greatest at bottom. In the shallower parts of the western basin (which basin includes all west of Malta, where a submarine ridge crosses the sea, and which has over a large part a depth of 1,500 fathoms, while the eastern is near 2,000, and even 2,150 fathoms in one part), the average specific gravity and chlorine at surface were 1·0278 and 20·87; at bottom 1·0285 and 21·38. But the salinity does not increase with the depth. An average of results shows that at 200 to 400 fathoms the specific gravity and chlorine were 1·0287 and 21·53; at 400 to 800 fathoms, 1·085, 21·38; at 1,300 to 1,700 f., 1·0283, 21·21. The increase of salinity for some distance downward is attributed to a

ing of the surface layer as it becomes more dense by evapora-
, an effect not apparent in the Atlantic, because the difference
alinity above and below is so slight.

.) The temperature of the North Atlantic waters near the mar of the basin decreases downward toward 35°, but with an ıpt falling off at 800 fathoms off the British Channel, near lat. The temperature at surface being 62°·6 to 64°·0 F., it was at 75 ., 49°·7; at 96, 51°·3; at 250, 50°·2; at 300, 49°·6; at 350, 1; at 450, 47°·6; at 557, 47°·0; at 600, 45°·5; at 725, 43°·9; 50, 42°·5; at 800, 42°·0; then a sudden fall of 3 degrees, the perature at 862 being 39°·7; at 1,000, 38°·3; at 1,250, 37°·7.

n the coast of Spain and Portugal, average lat. 39°, the tem- ıture at 81 fathoms was 53°·5; from which it gradually sunk 1°·5 at 300 fath.; 50°·5 at 600; 49°·3 at 800; and then fell off ıptly to 40°·3 at 862; 39°·7 at 1,000; 39°·7 at 1,250 fathoms.

r. Carpenter hence observes, "It appears clear that we have in latitude of Lisbon the same distinct separation between an *er warm* and a *lower cold* stratum as presented itself in the ınel between the Shetland and the Faroe Islands; but whilst 'stratum of intermixture' in the latter lies between 150 and fathoms, it lies in the former between 800 and 1,000 fathoms. eems perfectly clear that the *lower* stratum must have had a ır source; but there is no evidence that the *upper* stratum is ved from any source nearer the Equator. Its temperature, ed, is *lower* by 4° or 5° than that of the Mediterranean in the e parallel of latitude at corresponding depths; and since the perature of the latter may be considered as the *normal* of the ude,—this great inland sea being virtually excluded from icipation in the general oceanic circulation,—it would seem the effect of that circulation is rather to lower than to raise temperature of the upper stratum of this portion of the Atlan- Its surface-temperature during the summer is decidedly *lower* ı that of the Mediterranean under the same parallel; and the tation of the *super*-heating to its most superficial layer is in re accordance with our Mediterranean observations upon this ıt. As far as can be gathered from the data we at present pos- , the *winter* surface-temperature of this portion of the Atlan- is scarcely, if at all, higher than that of the Mediterranean er the same parallels. Hence it seems a justifiable conclusion neither the superficial layer, nor any portion of the upper stra- , of the Atlantic water that laves the coasts of Spain and Por- ıl receives any accession of heat from the extension of the f-stream into its area."

.) The temperature of the deeper waters of the Mediterranean ery nearly uniform, being between 54° and 56°·5, and nowhere ng below 54°; and this minimum cold is reached at a depth of ıt 100 fathoms. In a trial giving average results for the sea, re the temperature at surface was 77°, at 5 fathoms it was 76°; 0 f., 71°; at 20 f., 61°; at 30 f., 60°; at 40 f., 57°·3; at 50 f., 7; at 100 f., 55°·5. 54° was found at a depth in one case of

790 f.; 56° in another at 1,743 f.; 55° at 1,456 and 1,508 f., there being merely local variations. Hence "*whatever the temperature was at* 100 *fathoms, that was the temperature of the whole mass of water beneath down to the greatest depth explored.*" Between Gibraltar and Sardinia the bottom temperature ranged between 54° and 55°·5, average 54°·9; toward Sicily, between 55° and 56°·5.

Dr. Carpenter concludes that "no amount of *surface*-heat has power *directly* to affect the temperature of sea-water to a greater depth than 100 fathoms, the elevation of temperature it produces below 30 fathoms being very slight; and it seems also clear that the uniform temperature of from 54° to 56°·5, encountered below the 100 fathoms' stratum, represents the *permanent temperature* of the great mass of water which occupies the Mediterranean basin. Now this mass is entirely cut off from the influence of the general oceanic circulation; the surface-inflow through the Strait of Gibraltar having no other effect than slightly to lower the general temperature at the western extremity of the basin. And the uniform permanent temperature of the mass of Mediterranean water may thus be considered as representing the mean temperature of the earth in that region, slightly raised, perhaps, by a *downward convection* of heat from the surface in the manner to be presently described. With such an allowance, it corresponds closely with the determinations of the mean temperature of the crust of the earth in Europe, made by sinking thermometers into the ground to such a depth as to seclude them from the direct influence of summer heat or winter cold, but not to bring them within the direct influence of the internal heat of the earth. The temperature of deep caves gives another set of data of the like kind, which accord very closely with the foregoing. Thus, Mr. Pengelly states that the temperature in the part of Kent's Hole, at Torquay, which is farthest from its entrance, varies but little from 52° throughout the year. There is a cave in the island of Pantellaria, lying between Sicily and the African coast, which is reputed to be of 'icy coldness;' but Lieut. Millard, of H.M.S. 'Newport,' who has lately been making a careful survey of the island, informed us that, although he felt it 'very cold' on passing into it out of a very hot sunshine, its actual temperature, taken by thermometer, was 54°. And we have also learned, on good authority, that this is the temperature of the bottom of the deepest tanks in which water is stored up in Malta, provided that these are excavated (as is very commonly the case) beneath the houses, or are in any other way secluded from the direct rays of the sun."

(5.) The waters of the Mediterranean contain matter in suspension in a very fine state of division, which it derives from its rivers, and for its western basin largely from the Rhone. The bottom-water is almost everywhere turbid, and the bottom muddy. Very little life exists over it when thus muddy, and this is attributable to the fact that life cannot exist where there is a constant deposition of this finest silt going forward, as it tends to cover the surface of the animal and prevent aeration. Thus oyster beds will

›t flourish in the range of river deposits. The facts correspond ith those observed by Tyndal, who detected the particles in the ırface-water of the Mediterranean by electric light, and attrib- ;ed the deep blue color of the waters, as well as of those of Lake eneva, to their presence.

The facts are stated to explain to geologists how non-fossilif- ›ous argillaceous strata may have been formed in past time. Dr. arpenter suggests, as another reason for the absence of life over ıe bottom of the Mediterranean, the stagnation of the waters due › an almost total absence of vertical circulation. If this last .entioned cause is a true one, it should have excluded life from ıe bottom, where it is rocky, as well as from the muddy part.

4. *On the Geological Age and Microscopic Structure of the erpentine Marble or Ophite of Skye;* by Professors W. King ıd T. H. Rowney, (Proc. Roy. Irish Acad., Jan. 1871.)—*On the Iineral Origin of the so called "Eozoon Canadense,"* by the same .b., Apr. 10, 1871).—In the first of these papers, the authors ring out the facts with regard to the position of the rocks, and rive at their former conclusion that the ophite is an altered rock ; the Liassic period; and further show that the eozoon-like forms ; the Laurentian are paralleled in those of the skye ophite. In ıe second paper, Dr. Dawson's reply to the former memoir of lessrs. King and Rowney is considered in detail, and in closing, ıe following recapitulation is given of the points they consider as ıtablished:—

(1.) The serpentine in ophitic rocks has been shown to present ɔpearances, which can only be explained on the view that it under- ɔes structural and chemical changes, causing it to pass into ıriously subdivided states, and etching out the resulting portions .to a variety of forms—grains and plates, with lobulated or seg- ented surfaces—fibres and aciculi—simple and branching con- ;urations. Crystals of malacolite, often associated with the ser- ɔntine, manifest some of these changes in a remarkable degree.

(2.) The "intermediate skeleton" of "Eozoon" (which we hold › be the calcareous matrix of the above lobulated grains, &c.) is ›mpletely paralleled in various crystalline rocks—notably marble ›ntaining grains of coccolite (Aker and Tyree), pargasite (Fin- nd), chondrodite (New Jersey, &c).

(3.) The "chamber casts" in the acervuline variety of "Eozoon" ·e more or less paralleled by the grains of the mineral silicates in ıe pre-cited marbles.

(4.) The "chamber casts" being composed occasionally of ganite and malacolite, besides serpentine, is a fact which, instead favoring their organic origin, as supposed, must be held as a ·oof of their having been produced by mineral agencies; inas- uch as these three silicates have a close pseudomorphic relation- ip, and may therefore replace one another in their naturally escribed order.

(5.) Dr. Gümbel, observing rounded, cylindrical, or tuberculated ains of coccolite and pargasite in crystalline calcareous marbles,

considered them to be "chamber casts," or of organic origin. We have shown that such grains often present crystalline planes, angles, and edges; a fact clearly proving that they were originally simple or compound crystals that have undergone external decretion by chemical or solvent action.

(6.) We have adduced evidences to show that the "nummuline layer" in its typical condition—that is, consisting of cylindrical aciculi, separated by interspaces filled with calcite—has orginated directly from closely packed fibres; these from chrysotile or asbestiform serpentine; this from incipiently fibrous serpentine; and the latter from the same mineral in its amorphous or structureless condition.

(7.) The "nummuline layer," in its typical condition, unmistakably occurs in cracks or fissures, both in Canadian and Connemara ophite.

(8.) The "nummuline layer" is paralleled by the fibrous coat which is occasionally present on the surface of grains of chondrodite.

(9.) We have shown that the relative position of two superposed asbestiform layers (an *upper* and an *under* "proper wall"), and the admitted fact of their component aciculi often passing continuously and without interruption from one "chamber cast" to another, to the exclusion of the "intermediate skeleton," are totally incompatible with the idea of the "nummuline layer" having resulted from pseudopodial tubulation.

(10.) The so-called "stolons," and "passages of communication exactly corresponding with those described in *Cycloclypeus*," have been shown to be tabular crystals and variously formed bodies, belonging to different minerals, wedged cross-ways or obliquely in the calcareous interspaces between the grains and plates of serpentine.

(11.) The "canal system" is composed of serpentine, or malacolite. Its typical kinds in the first of these minerals may be traced in al' stages of formation out of plates, prisms, and other solids, undergoing a process of superficial decretion. Those in malacolite are made up of crystals—single, or aggregated together—that have had their planes, angles, and edges rounded off, or have become further reduced by some solvent.

(12.) The "canal system" in its remarkable branching varieties is completely paralleled by crystalline configurations in the coccolite marble of Aker, in Sweden; and in the crevices of a crystal of spinel imbedded in a calcitic matrix from Amity, New York.

(13.) The *configurations*, presumed to represent the "canal system," are *totally without any regularity* of form, of relative size, or of arrangement; and they occur independently of, and apart from, other "eozoonal features" (Amity, Boden, &c.); facts not only demonstrating them to be purely mineral products, but which strike at the root of the idea that they are of organic origin.

(14.) In answer to the argument that as all the foregoing "eozoonal features" are occasionally found together in ophite, the

ıbination must be considered a conclusive evidence of their ·anic origin, we have shown, from the composition, physical ıracters, and circumstances of occurrence and association of ir component serpentine, that they represent the structural and ɜmical changes which are eminently and peculiarly characteris- of this mineral. It has also been shown that the combination ɔaralleled to a remarkable extent in chondrodite and its calcitic trix.

(15.) The "regular alternation of lamellæ of calcareous and ceous minerals" (respectively representing the "intermediate ɛleton," and "chamber casts") occasionally seen in ophite, and ısidered to be a "fundamental fact" evidencing an organic ·angement, is proved to be a *mineralogical* phenomenon by the t that a similar alternation occurs in amphiboline-calcitic marbles d gneissose rocks.

(16.) In order to account for certain *untoward* difficulties pre- ıted by the configurations forming the "canal system," and the .culi of the "nummuline layer"—that is, when they occur as *olid bundles*"—or are "*closely packed*"—or "*appear to be glued ɩether*"—Dr. Carpenter has proposed the theory that the sarcodic tensions which they are presumed to represent have been urned into stone" (a "siliceous mineral") "by Nature's cun- ıg" ("just as the sarcodic layer on the surface of the shell of ing foraminifers is formed by the spreading out of *coalesced* ndles of the pseudopodia that have emerged from the chamber ıll")—"by a process of chemical substitution *before* their struction by ordinary decomposition." We showed this quasi- ɛhymical theory to be altogether unscientific.

(17.) The "siliceous mineral" (serpentine) has been analogued th those forming the variously-formed casts (in "glauconite," :.) of recent and fossil foraminifers. We have shown that the neral silicates of "Eozoon" have no relation whatever to the bstances composing such casts.

(18.) Dr. Hunt, in order to account for the serpentine, loganite d malacolite, being the presumed in-filling substances of Eozoon," has conceived the "novel doctrine" that such minerals ɪre *directly* deposited in the ocean waters in which this "fossil" ed. We have gone over all his evidences and arguments with- t finding *one* to be substantiated.

(19.) Having investigated the alleged cases of "chambers" and ubes" occurring "filled with calcite," and presumed to be "a nclusive answer to" our "objections," we have shown that there ɜ the strongest grounds for removing them from the category of iable evidences on the side of the organic doctrine. The Tudor ɜcimen has been shown to be equally unavailable.

(20.) The occurrence of the best preserved specimens of "*Eozoon ınadense*" in rocks that are in a "*highly crystalline condition*" awson) must be accepted as a fact utterly fatal to its organic gin.*

* Dr. Carpenter, unable to defend himself against Mr. T. Mellard Reade's ɜction that "Eozoon" *occurs only in metamorphosed rocks* (*Nature*, No. 60),

(21.) The occurrence of "eozoonal features" ***solely*** in crystalline or metamorphosed rocks, belonging to the Laurentian, the Lower Silurian, and the Liassic systems—never in ordinary unaltered deposits of these and the intermediate systems—must be assumed as completely demonstrating their purely mineral origin.

The authors add to the paper the following *postscript.*

The reading of the foregoing paper was followed by a short communication from Dr. Dawson, on "two points," which it is now necessary to notice:—

One relates to some fragments of Silurian crinoids, the "cells and tubes" of which are in the state of casts composed of "amorphous hydrous silicate of alumina and ferrous oxide, with some magnesia and alkalies," also, "angular and partially rounded grains of quartzose sand"—evidently a super-aluminous example of the widely varying mixtures, known as glauconite, green-earth, &c. The case is interesting: but, never having denied the well-established fact that foraminiferal shells, corals, and other organisms occur with siliceous in-fillings of the kind—and having already determined the attempt to assimilate such substances with a certain class of minerals to be utterly unsupported by any proper evidences—we do not see the pertinency of introducing it (and some others made known last year by Dr. Carpenter) into the present discussion. Besides, it is altogether gratuitous, and inconsistent with scientific reasoning, to assume that the crinoidal in-filling "is similar to that effected by the ancient serpentine of the Laurentian" (Dawson); or, that it is "allied in the mode of its formation to the serpentine, pyroxene, and other minerals which have injected Eozoon" (T. Sterry Hunt).

The other relates to our statement of the occurrence of an essential "eozoonal feature" in connexion with a crystal of spinel, from Amity. We now learn that Dr. Dawson has had under examination specimens of spineliferous rock from the latter place:—and, notwithstanding his having pronounced the case as "*so unlikely*," the result is, that the specimens have been found to "contain in spots, remains of casts of canals similar to those of *Eozoon Canadense*." As to the inference that the specimens "are portions of a bedded rock, and not a vein stone"—without taking into consideration that it is suppositional, and based on an examination of specimens preserved *in collections*—it cannot set aside the plain fact, that in our specimen arborescent configurations—formed of groups of decreted crystals of malacolite, and identical

takes refuge under the *ad captandum* argument, that its "calcareous lamellæ" ("intermediate skeleton") "show less departure from the shelly texture than do the great majority of undoubted shells, corals, &c., contained in the least altered rocks of any geological period" (*Nature*, No. 62): forgetting that, as the substance of such fossils has undergone so much change, the fact demands a vast amount of metamorphism to convert the rocks containing them—"least altered" as they may be—into the "highly crystalline condition" of "eozoonal" ophite. But Dr. Carpenter seems to misunderstand the objection altogether; as it is not based so much on the mineral structure of the "eozoonal features," as on the fact that they occur best preserved in "highly crystalline" or metamorphosed rocks.—K. & R.

;h perfect and the finest examples of what are presumed to be asts of the canal system"—are present in calcite, occupying the vices of a large crystal of spinel. The fact of itself conclusively tles their purely mineral origin.

5. *On the Oil-bearing Rocks of Ohio and West Virginia;* by J. WARNER. (Communicated.)—In an article on the "Oilaring Limestones of Chicago," in the June number of this Jourl, by Prof. T. Sterry Hunt, this author remarks that "much of e petroleum of Pennsylvania, Ohio, and the adjacent regions, is ligenous to certain sandstones in the Devonian and Carbonifers rocks."

It is now well ascertained that the heavier lubricating oils, proiced along the well known uplift in West Virginia, are found in e crevices of the two lower members of the Carboniferous sandones, namely, the conglomerate proper, and the next overlying ndstone stratum, the two being separated by from seventy to ie hundred feet of shales. The light petroleum produced in this me district is principally found about three hundred and fifty et below the Coal-measure conglomerate, or in the Upper Devoan shales. In the region of Sand Hill, where the uplift reaches maximum elevation, the base of the conglomerate is brought to ithin about three hundred feet of the surface. The Subcarbonrous limestone, as well as all true representatives of the Vesperie and Umbral of Prof. Rogers, seem here to be wanting. Nor the depth at present attained by boring is there any well-defined true sandstone, the light oil being found rather in a coarse darkenaceous shale.

In the Cow Run oil district in Ohio, which lies northward from e Virginia district, and along a low but quite sharp anticlinal lt—whether strictly an extension of the West Virginia anticlinal not, seems as yet unascertained—the oil, which is here of light avity, is found principally in the sandstone stratum, which forms part of the hills in the West Virginia district, and is doubtless e Mahoning sand of the Pennsylvania survey. In this district e conglomerate is passed through at a depth of about twelve indred feet. While in Virginia the crevices of the conglomerate ere filled with oil, the lighter portion of which had escaped by aporation, in Ohio in the same rock but little oil is found, while rong salt water fills most of the crevices.

Now, while these several sand rocks, where they come to the rface, contain Calamites, Stigmaria, and other fossil plants of the wer Coal-measures, they contain nothing from which petroleum uld possibly have been derived.

Again, if the oil originates in the sandstones where it is found, hy is it limited strictly to these sharp anticlinal belts? The evience seems abundant, that, at least in the districts under considation, the oil comes from lower strata, but whether from the arer Genesee and Marcellus slates, or the deeper Silurian limeones, may, perhaps, be yet a question; but facts which would reiire too much space to ask for here, favor the view of the nearer urce in the bituminous shales.

Marietta, Ohio, July 12.

6. *Notes on some points in the Mineralogy and Geology of Utah;* by W. P. Blake. (From a letter to Prof. B. Silliman, dated Salt Lake City, July 27, 1871.)—I left New Haven hurriedly to reach the Emma Mine and examine it. It is a remarkable mine. Within a little more than a year it has yielded ore worth over \$2,000,000, and this without any special outlay. It is a great mass of soft earthy-looking ore, the result of the decomposition of argentiferous galena. It is dug out with shovels and picks, sacked, and sent to Liverpool, where it sells for about \$175 per ton. The mass is between strata of limestone, the middle members of a series of strata over a mile thick. The lower members are slate and quartzite, and rest upon the immense masses of syenitic granite which form the picturesque Alpine-like peaks of the Wahsatch. These strata are all much uplifted and contorted, some of the harder beds surging up into peaks at least 11,000 feet above tide. The mine is at an elevation of 8,500 to 9,000 feet. At the head of the cañon upon the side of which it is situated, there is a fine exposure of syenitic granite for about a mile, with rounded polished backs—*roches moutonnées*—probably 9,000 above tide. These rocks give conclusive evidence of the former existence there of a large glacier. Much of the polish upon the surface has been removed by the action of the weather. The patches that remain are dark brown in color, while the syenite is light gray, and they show the same peculiar scale-like crusts seen on the partly weathered glaciated surfaces above the Yosemite.

In addition to the carbonate of lead, the mingled oxides of lead and antimony, etc., found generally in the decomposed lead ores of the limestone formation, I have seen some peculiar and interesting species from other parts of the Territory. *Sal Ammoniac* is shown here in large masses from the southern part of Utah. It is remarkably pure and free from iron. *Trona* is now about to be largely produced from the shallow lake on the Sweetwater, near Independence Rock. *Cinnabar* occurs in Camp Floyd District. *Bismuthinite* is likely to be produced in considerable quantity from a vein in syenite recently opened by Messrs. C. F. and J. B. Meader in the southern part of the Territory. It is associated with pyrites, brown dodecahedral garnets, and considerable hornblende.

7. *Note on Coal-measure Fucoids;* by G. C. Broadhead.—(Communication dated Pleasant Hill, Mo., July 14th, 1871.)

I have been interested in two communications in the June and July numbers of the Journal regarding *Caulerpites* and coal-plants. In Owen's second Report on the Geology of Arkansas, p. 302, Lesquereux reports the occurrence of *Fucoides Cauda-galli* in a sandstone of Crawford Co., Arkansas, in the neighborhood of the coal-fields. Considering it Devonian, he is puzzled at its occurrence there, and suggests the possibility that it has "a much wider range of distribution than had till now been supposed." He adds that "in some places, along the margin of the eastern coal-basin of Kentucky, the Conglomerate is sometimes underlaid by this formation of the *Fucoides Cauda-galli.*" I think

ıt further investigation would show this Crawford Co. sandstone belong to the Coal-measures.

I observed the *Caulerpites* first, about the year 1859, in Ranlph Co., Mo., occurring in hard sandstone and sandy limestone the Coal-measures, and not very remote from the base of the ›wer series: it was there about five feet below a four-foot bed coal. I have observed traces of the same, here at Pleasant Hill, Upper Coal-measure sandstone and sandy limestone, and at one her locality in Missouri—I think probably in Lafayette Co. In 68, I discovered *Caulerpites* in a shaly sandstone of the Upper ›al-measures, in Montgomery Co., Illinois, above the horizon of al No. 13.

8. *On Carboniferous and Subcarboniferous Fossils in Mononlia Co., West Virginia;* by F. B. Meek (Report Regents of niversity, W. Virginia).—Mr. Meek describes in this paper some w species, viz: *Macrodon obsoletus*, of the Lower Coal-measures, *ucula anodontoides*, *Yoldia Stevensoni* and *Y. Carbonaria* of e Coal-measures, and *Phillipsia Stevensoni*, from the Chester oup of the Subcarboniferous. From a survey of the species colcted, he concludes that the Chester group (of the Illinois Reports) represented in Western Virginia by at least six Illinois species, ıd along with ten or a dozen other species which he could not entify because of the imperfect state of the specimens. The ds also contain *Hemipronites crassus*, a Coal-measure species, d a *Cyrtoceras* and *Bellerophon*, closely like species of the Coaleasures. He observes that Monongalia County is the farthest int eastward at which the Chester group, or indeed any other the divisions of the Subcarboniferous limestones of the West, s yet been recognized. The species from the lower Coal-meases are mostly the same that occur in the Coal series of Indiana, inois, Missouri, Kansas, Nebraska, etc., though few of them ve before been found so far eastward. In some of the States entioned, nearly all of the species range through the whole of e Coal-measures, showing, as Mr. Meek remarks, that species ed on through a great length of time, and consequently that the imatic and other physical conditions of the era must have mained remarkably uniform.

9. *On the Stratigraphic Relation of the Orders of Reptilia;* by of. Edward D. Cope.*—The stratigraphic relation of the orders Reptiles is shown in the following table:—

Present—Rhynchocephalia; Crocodilia; Testudinata; Lacertilia; Ophidia.
Pliocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Miocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Eocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Cretaceous—Ornithosauria; Dinosauria; Crocodilia; Sauropterygia; Testudinata; certilia; Pythonomorpha.

* From a Memoir on the Homologies of some of the Cranial bones of the ptilia and the Systematic Arrangement of the Class, in the Proc. Am. Acad. ston), xix, 194. On the preceding page of the memoir the author argues that supposed *Lacertilia* of the Permian are all *Rhynchocephalia*.

Jurassic—Ornithosauria; Dinosauria; Ichthyopterygia; Crocodilia; Sauropterygia; Testudinata; Lacertilia.

Triassic—Dinosauria; Anomodontia; Rhynchocephalia; Ichthyopterygia; Crocodilia; Sauropterygia; ? Testudinata. ?

Permian— ? Rhynchocephalia.

It will be observed, by this table, that the most specialized Reptilian order, the Ophidia, appeared last in time in the Eocene period; and that those which constitute the line of connection with the generalized reptiles appeared earlier as they approached the latter,—the Pythonomorpha in Cretaceous, and Lacertilia in Jurassic times. The Reptilian groups most specialized in bird characters (Ornithosauria and Dinosauria) appear on the other hand very early; the first and most mammalian also,—the latter of the two, in Jurassic beds. The Trias gives us in the Anomodontia and Ichthyopterygia the two most generalized and lowest orders; while their contemporary, the Rhynchocephalia, almost as much generalized in Reptilian features proper, was already represented in the Trias. Strangely enough this order yet exists in the living Sphenodon of New Zealand. The Crocodilia, rather specialized in bird characters, accompanies the last in this wonderful persistency, beginning also in the Trias.

The inquiry as to the truth of the proposition that the more ancient types of animals are more generalized, and therefore more embryonic in the characters of a special nature* which characterized groups later introduced, is answered in a very imperfect way in the affirmative. It is like the shadow of a truth whose substance will shortly come before us. But when we come to compare the subdivisions of the orders themselves with each other, and with those of other orders, as we pass backward in time, the weight of the affirmative answer to the above proposition is greatly increased. The oldest Ophidia are boæform, therefore approaching Lacertilia and Pythonomorpha. The oldest Tortoises have generally the most incomplete carapace and plastron; among them the Psephoderma allied to Sphargis, without carapace, and thus the most lizard-like of the order. The Lacertilia of European Jurassic strata are, some of them at least, acrodont, apparently Pachyglossa (*e. g.*, Acrosaurus), and, as such, nearer the Rhynchocephalia, which preceded them in time. The position of Homorosaurus and Piocormus is not determinable, as the dentition cannot be understood from the descriptions and figures of Wagner. The form of the mesosternum of the former refers it to either the Pachyglossa or Iguana, as I understand those groups. It may be assumed that since the order Lacertilia has diverged from the line of other Reptilia, while it took on in its special peculiarities, it lost in the features characterizing the main series with a higher tendency or terminus, thus *retrograding* in one sense. This is seen in the shortened sacrum, pleurodont dentition, etc.

The Crocodilia of the Jurassic do not possess the ball-and-socket-jointed vertebræ of the recent genera, and exhibit the plane articular faces of all the Jurassic and Triassic Reptilia. Their

* The identity of these two propositions has not always been noticed by authors.

asicranial region is also plane like that of other orders, instead of ertical as in the recent forms. The Triassic Crocodiles are still iore generalized. Their ribs are extended to the pelvis, as in)inosauria and Anomodontia: there are often three sacral vertezræ, an approach to the long sacrum of the same orders. The emur, with third trochanter, is an approach to that of the Dinoauria; and finally the position of the nostrils near the orbits (Beodon) is a Sauropterygian feature. In the Sauropterygia the hortened vertebral column, and long muzzle (Pistosaurus) in the ldest types (Triassic), are approximations to the Crocodilia. The)inosauria display an increasingly Crocodilian character as we ass into the Triassic period. The femur (Palæosaurus), Megadacylus) loses the bird-like head, and assumes the ill-defined convexity f the Crocodiles; the tibia (Plateosaurus) loses the bird-like ' spine," or crest. The illium is shorter (Palæosaurus). Every tudent of the subject knows how much more difficult is the sepaation of the bones of Sauropterygia, Crocodilia, Anomodontia and)inosauria, of the Trias, than those of the Cretaceous. There are ypes allied to the Rhynchocephalia, whose systematic position is loubtful, owing to the generalized character of the parts we posess. Thus the Rhynchosaurus of the Trias of England is allied o that order, and to the Anomodontia. The Rhopalodon of the ?ermian has a large canine tooth, like the single one possessed by he Anomodontia; but with others associated, like those of the Rhynchocephalia. The Triassic Sauropterygia and Rhynchocehalia also agree in the anterior production of the pterygoid bones etween the palatines to the vomer. Compare, for this point, Hyerodapedon and Nothosaurus.

We learn from such considerations as the above, and similar nes derived from the study of the Mammalia, that the successional elation of the faunæ of the periods in geologic time is more strikngly exhibited by the subordinate contents of the orders than by the orders themselves, in relation to each other. From this we lecide that we must look for the origin of the orders in periods prior to those in which we now know them, if, as some suppose, hey originated in still more generalized types. This accords with Huxley's view of the period of origin of the mammalian orders.

It must also be remembered that the above deduction as to geological distribution is precisely that of geographical distribuion; *i. e.*, that the homologous groups of different continents are not orders, but subordinate divisions of orders, the orders being universally distributed. This coincidence is remarkable, and justifies the view I have taken of the origin of higher types on the basis of retardation and acceleration, and of the nature of synchronism.*

10. *Endurance of Heat by Infusoria;* by F. C. Calvert. 'Am. Mag. N. H., IV, viii, 129).—A solution of sugar in which nfusoria had appeared, when subjected to 212° F., still contained 1 or 5 small black Vibrios quite active, and 2 or 3 energetic ordinary

* Origin of Genera, 1868; Hypothesis of Evolution, 1870.

Vibrios. The same, heated to 300° F., was found to contain 2 ordinary Vibrios and 1 or 2 black Vibrios. At 400° F. the sugar was mostly decomposed and all life had disappeared.

An infusion of hay was similarly treated; after heating to 212° F., there were present a few small black Vibrios; and even after heating to 300° F., though a less number. None was found after heating to 400°. 212° F. destroyed all the fungous matter that was before present in the tubes.

The life in an infusion of gelatine was slightly decreased at 100° F., very largely at 212° F. and had wholly disappeared at 300° F.

The infusoria in putrid meat fluid were but slightly affected at 100° F.; at 212° F. a small part remained alive but inactive, the liquor becoming turbid and coagulated; at 300° F., a few Vibrios were alive, the small black ones the most numerous; at 400° F. all life had disappeared.

In each case the infusions were examined 24 days after the heating. The results show that infusorial vegetable life of some kinds may survive a temperature of even 300° F., but not of 400° F.

At 15° F. the infusoria became languid, but with an increase of temperature again they were as active as ever.

11. *Metschnikoff on the affinities of Crinoids.*—Metschnikoff, to whom we owe so many valuable embryological investigations, has published preliminary notices* of the early stages of Comatula which are of the utmost importance, as they throw an entirely new light on the affinities of the Crinoids. Thoroughly familiar with the Pluteus of Holothurians, Echini, Starfishes and Ophiurans, he commenced the investigation of their earlier stages with the determination of tracing the presence of the peculiar water-system of the larvæ of the other orders of Echinoderms, what had been previously written by Busch, Allman and Thomson, on the early stages of Comatula, giving no data whatever bearing upon the subject.

To his surprise he found no such water-system, nor could he trace anything in any way homologous to it; he also discovered that what constitutes the water-system of adult Crinoids, which has always been homologised with the water-system of other Echinoderms is developed in a totally different manner. In the free swimming Comatula larva the bag-like digestive sac is the only organ developed, it becomes the digestive cavity of the adult after the larva attaches itself to the ground. He noticed the tentacles as diverticula of the digestive sac in the interior of the larva; these subsequently force their way through to the exterior, at the time when the digestive bag has become further differentiated, and is provided with a mouth opening in the center of the oval disk, and an anus opening not far from it on the side of the calyx. There is formed at this stage a large cavity which divides into two parts; the upper part, uniting the hollow

* Bulletin Acad. St. Petersburg, xv, p. 508, February, 1871.

tentacles at their base, forms the so-called circular canal, while below it, and connecting with it, we have a large cavity forming the perivisceral cavity, a mode of development of the circular ring and of the perivisceral cavity totally unlike that observed in Ophiurans, Starfishes, Echini and Holothurians.

Metschnikoff compares the mode of development of the upper and lower cavity to analogous processes in the embryonic growth of Alcyonella and other Bryozoa; he traces a striking similarity in the structure and position of the digestive organs and tentacles with similar organs of Bryozoa. However that may be, he has shown conclusively that the larva of Comatula has apparently nothing in common with other Echinoderm larvæ; but we must wait for his figures on this intricate subject before we can decide if the position he assigns to Crinoids is true to nature. A. AG.

12. *Chinese Botany.*—We have received, through the kind attention of the author, a curious pamphlet, of 50 pages, *On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources;* by E. Bretschneider, M.D., Physician of the Russian Legation at Peking. Illustrated with 8 Chinese wood-cuts. Printed at Foochow. The preface bears the date of Dec. 17, 1870. In it the author declares that he is "neither a Sinologue nor a Botanist;" his "knowledge in Chinese as well as in botany being very limited." But his enquiries on the spot under advantageous conditions, and the use he has made of "the splendid library of the Russian Ecclesiastical Mission at Peking, where are to be found not only all Chinese works of importance, but also most European books relating to China," have not been fruitless. The pamphlet, not to speak of critical matters, is full of interesting information concerning esculent, medicinal, and other economical plants, natives of China or of early introduction, and the question of nativity or the source of introduction is treated of by the aid of Chinese documents, some of them of high antiquity. Cotton appears to have been of comparatively recent introduction, having reached China in the 9th or 10th century, from Central Asia and Cochin China. Contrary to some authorities, "it can be proved from Chinese sources that Maize and Tobacco are not indigenous in China." But the *Batatas*, or Sweet Potato, held to be of American origin, "was described in Chinese books a long time before the discovery of America, i. e., in the third or fourth century." Sugarcane did not pass from China to India, but the reverse, and as early as the second century B. C., although it was several centuries later that a native of India taught the Chinese to make crystallized sugar, or "stone honey." A. G.

13. *Plants killed by Frost: do they die in Freezing or in Thawing?*—That in certain cases plants die in freezing, is shown by Prof. Gœppert, of Breslau, in a very satisfactory way, in an article in a recent number of *Bot. Zeitung.* The flowers of certain Orchids, notably the milk-white blossoms of *Calanthe veratrifolia*, produce indigo; but only upon a chemical reaction, which

takes effect upon the death of the parts. When crushed, or the cells in any way destroyed as to vitality, they turn blue immediately. Now, upon exposure to cold, the flowers turn blue at once upon freezing, showing that life then departed. *Phaius grandiflora* and other species of that genus are said to show the same thing.

A. G.

III. Astronomy.

1. *Scintillation of the Stars.*—Prof. L. Respighi has published an extended and very interesting paper upon this subject, it being an extract from the proceedings of the Accademia Pontificia de Nuovi Lincei, at the session held Febr. 14, 1869. It gives the results of a great number of observations made with the spectroscope upon stars of different magnitudes, and with every variety of circumstance as to elevation, azimuth, atmospheric conditions, and the like. The first portion of the paper is a *resumé* of an earlier one giving the results of a series of observations made previously to May 1868. The conclusions arrived at, although incomplete, were so important, that Prof. Respighi made a more extended series of over 700 observations, which were continued from October, 1868, to February, 1869. The instrument employed was an equatorial by Merz, with an aperture of 4½ inches, and provided with a direct-vision prism by Hoffmann, with a cylindrical lens between the prism and the ocular.

When the telescope was directed toward a star near the horizon, the spectrum of the star with its characteristic lines was seen, and in addition to these, broad bands, usually dark, very rarely bright, which slowly traversed the spectrum from one end to the other, passing from the violet to the red, when the star was in the east, and in the opposite direction when it was in the west. The characteristic phenomena, as summed up by Prof. Respighi, are as follows.

(1.) In normal atmospheric conditions, the motion of the bands is from the red to the violet for stars in the west, and from the violet to the red for stars in the east.

(2.) Near the meridian, whether north or south, the motion generally oscillates from one color to the other, and sometimes the bands appear stationary, or traverse only a portion of the spectrum.

(3.) The motion of the bands is more regular and less rapid near the horizon, while at greater altitudes it is less regular and more rapid.

(4.) When the instrument is so placed that the spectrum is vertical, the motion of the bands is the same as when it is horizontal, but the bands are less definite, and nearly transversal, up to an altitude of 80°; while for greater altitudes they become successively more indistinct, changing into longitudinal bands, and sometimes into mere moving masses either bright or obscure, and not rarely resulting in mere changes of brightness.

(5.) The bright bands are more rare and less regular than the dark ones, and occur only near the horizon.

(6.) Not unfrequently, in the case of stars of low altitude, besides the bands which are regular, there occur other series of bands less regular and more inclined, and sometimes also longitudinal.

(7.) Under normal atmospheric conditions, neighboring stars all present the same phenomena.

(8.) Under abnormal conditions of the atmosphere, the bands are more feeble and more irregular in form and movement.

(9.) When high winds prevail, the bands are very faint and indistinct, and sometimes appear as mere changes of brightness in the spectrum, even when the stars are near the horizon, and very bright.

(10.) When the images of the stars are very diffuse, the bands are most feeble and indistinct.

(11.) When the bands are regular in form and movement, there is generally good weather; and it would appear in general that regularity in the phenomena of scintillation is a reliable basis for predicting the continuance of fair weather.

(12.) The phenomena of scintillation are most distinctly marked on evenings of greatest atmospheric humidity.

Prof. Respighi then discusses the cause of the scintillation as indicated by the phenomena observed. The regularity and constancy, both in direction and velocity, of the motion of the bands with respect to the meridian, namely, from red to violet for stars in the west, and from violet to red for those in the east, shows that it cannot be attributed to ascending or descending movements of the atmospheric masses, but must be due to some more general cause; and he concludes that this cause is the rotation of the earth, by which the luminous rays are carried through atmospheric strata of varying density.

For, in traversing the air, the path of the least refrangible rays would present the least deviation from a straight line, and that of the most refrangible the greatest. Of the rays which pass into the instrument or the eye therefore, the violet must enter the atmosphere at a more elevated point than the red rays. Hence the cone of rays if traced backward from the eye toward the star would be spread out into a vertical spectrum, with the most refrangible rays uppermost, and the others lying successively lower in their order. The curvature of the rays in passing through the air, as affecting the different rays in the same direction, may be neglected. Prof. Respighi finds by calculation, that for a star near the horizon, the breadth of this spectrum at a distance of 90 kilometers from the observer would be not less than 10 meters, and near the limits of the atmosphere it must be several times as great.

Now the rotation of the earth carries the luminous cone onward, causing the rays to traverse successively different portions of the atmosphere. If there are heterogeneous strata in the latter from condensation or rarefaction, these would act successively upon the different colors of the cone in their order. Toward the west, the motion of the air, relatively to the cone, is upward, and hence

the red rays of the latter are encountered by it first. In the east the phenomena occur in the reverse order, the violet rays being the first to be affected.

Now the dispersion of the rays, for a star near the horizon, corresponds to a very small angle at the eye of the observer, and a very slight increase or decrease in the density of a portion of the air may cause a considerable deflection of a ray from its normal path.

If then the star observed is in the east, the mass of air will meet the violet end of the spectrum first, and as its refracting power is changed with its density, the violet rays will be deflected. They will thus be thrown out of the spectrum, causing a dark band, which will advance through the other colors, as the mass of air travels through the other portions of the cone of rays. If the star is toward the west, the mass of air will meet the red end of the spectrum first, and the dark band will pass from the red to the violet. At or near the north and south points, as the atmospheric motions would in general be transverse to the spectrum formed in the air, the bands, if formed at all would move in either direction indifferently, and present great irregularities.

As the elevation of the star increases, the length of the atmospheric spectrum becomes less and less, as the incidence of the rays becomes more nearly normal, and the bands traverse it with correspondingly greater velocity. Above 40° of altitude, Prof. Respighi has found that the cone of rays differs so little from a cylinder that the effects above described are scarcely perceptible.

Again, taking the divergence of the rays at the eye of the observer as about 11″, which is probably near the truth, as the angle described by the earth in one second is 15″, the time occupied by a dark band in passing the whole length of the spectrum would be somewhat less than one second, and in the observations the time was found to be not far from this.

Considering the complete agreement of these deductions with the phenomena observed, Prof. Respighi concludes that the cause of the scintillation is to be found in the actual subtraction of a portion of the rays by the unequal refraction of the masses of air through which they are caused to pass by the rotation of the earth, and he is thus led to reject both the explanation of Arago, according to which it is due to interference, and that of Montigny who ascribed it to the total reflection of a portion of the rays by strata of air unequally heated.

In the case of the planets, owing to the breadth of their disks, the spectra are superposed, and the phenomena are in general not distinctly seen, as they produce ordinarily simple changes of brightness, or mere irregular oscillatory movements of the images. In observations upon the brighter planets, however, especially Venus, when near the horizon, Prof. Respighi has occasionally, under favorable circumstances, recognized the same phenomena as are displayed by the fixed stars. A. W. W.

2. *On the recent Solar Eclipse;* by J. NORMAN LOCKYER.—r. Lockyer closes an interesting lecture on the Solar Eclipse, livered before the Royal Institution, on March 17th, as follows: I will proceed now, if you will allow me, to some of the general sults obtained during the last eclipse.

I think that, although the work has been very unfortunately terrupted, still the result has been most satisfactory. By putting gether observations here and observations there, I consider that r knowledge of the sun is enormously greater than it was a few onths ago. For instance, we are enabled to understand the long-glected observation of Rayet, and the equally long-neglected servation of Pogson; and we know that outside the hydrogen ere is, in all probability, a new element existing in a state of nost infinite tenuity. And we are sure of the existence of cool drogen above the hot hydrogen, a fact which seemed to be gatived by the eclipse of 1869.

I think, if we had merely determined that there was this cool drogen, all our labor would not have been in vain, as it shows e rapid reduction of temperature; but there is more behind. I ld you that M. Mädler, in summing up the observations made to 1860, came to the conclusion that part of the corona was cer-nly solar, and that whether the outer portions were or were not lar, was a matter of doubt. I do not say that we have settled at absolutely, but we have firm evidence that *some* of the light the corona is due to reflexion between the earth and the moon. ie outer corona was observed to have a rosy tinge over the prom-ences, and the spectrum of the prominences was detected many nutes above them, as well as on the dark moon. It could not ve got this color *at the sun*, for its intrinsic color is green, and e red light of the hydrogen supplied at the sun is abolished ogether, is absorbed, and can only reach the corona *at the sun*, to speak, as dark light.

It is a great fact that we are sure, as far as observation can make sure, that there is a glare around the hydrogen which gives us spectrum of hot hydrogen on the corona, *where we know that t hydrogen does not exist.* Assume the hot hydrogen which res us the red light to be only two minutes high, the spectro-ope has picked it up eight minutes from the sun! The region of ol hydrogen is exaggerated in the same way. We get it where ere is no indication of the cool hydrogen existing. And then, th regard to the element which gives us the line of the green, we t that twenty minutes or twenty-five minutes away from the sun. ell, no man who knows anything about the matter will affirm it it is certain that the element exists at that distance from the sun. Therefore I think we have absolutely established the fact that the sun—the uneclipsed sun—gives us a glare around it, so each er of the chromosphere gives us a glare around it. That is ictly what was to be expected, and that it is true is proved by observation—a most important observation made in Spain—

that the air, the cloud, ever between us and the dark moon, gives us the same spectrum that we get from the prominences themselves.

Given, however, the layers and elements in the chromosphere extended as far as you will, and apparently increased or not by reflexion *not at the sun*, we have still to account for rays, rifts, and the like. If anyone will explain either Mr. Brother's photograph or Mr. Gilman's picture of the eclipse of 1869, containing those dark bands starting from the moon and fading away into space, and the bright variously-colored rays between them, on any solar theory, he will render great service to science. But in the meantime I must fall back upon M. Mädler's opinion of 1860, with the addition to it that I have stated that we have found, at all events, *that some* of the doubtful light is now solar; we have turned the opinion into a fact.

Bear in mind that close to the sun you have a white layer composed of vapors of many substances, including all the outer ones; outside this is a yellow region; above that a region of hydrogen, incandescent and red at the base, cooler, and therefore blue, higher up, the red and blue commingling and giving us violet; and then another element thinning out and giving us green. Take these colors in connection with those which are thrown on our landscapes or on the sea during eclipses, each region being lighted up in turns with varying, more or less monochromatic, light, and that light of the very color composing the various layers, each layer being, as I have shown, so much brighter than the outer ones that its light predominates over them. Is it too much to suggest to those who may be anxious to attempt to elucidate this subject, that probably if they would consider all the conditions of the problem presented by that great screen, the moon, allowing each of these layers by turn to throw its light earthward, the inequalities of the edge of the *globular* moon allowing here light to pass from a richer region, here stopping light from even the dimmer ones, they would be able to explain the rays, their colors, variations, apparent twistings, and change of side? I do not hesitate to ask this question, because it is a difficult one to answer, since the whole question is one of enormous difficulty. But difficult though it be, I trust I have shown you that we are on the right track, and that in spite of our bad weather, the observations made by the English and American Government Eclipse Expedition of 1870 have largely increased our knowledge.

With increase of knowledge generally comes a necessity for changing the nomenclature belonging to a time when it was imperfect. The researches to which I have drawn your attention form no exception to this rule. A few years ago our science was satisfied with the terms prominences, sierra, and corona, to represent the phenomena I have brought before you, the nature of both being absolutely unknown, as is indicated by the fact that the term *sierra* was employed, and aptly so, when it was imagined the prominences might be solar mountains! We now know many of the constituent materials of these strange things; we know that

are dealing with the exterior portion of the solar atmosphere, a large knowledge of solar meteorology is already acquired, ch shows us the whole mechanism of these prominences. But also know that part of the corona is not at the sun at all. ıce the terms *leucosphere* and *halo* have been suggested to ıgnate in the one case the regions where the general radiation, ng to a reduced pressure and temperature, is no longer subor- ate to the selective radiation, and in the other, that part of the ɔna which is non-solar. Neither of these terms is apt, nor ither necessary. All purposes will be served if the term ɔna be retained as a name for the exterior region, including rays, rifts, and the like, about which doubt still exists, though s now *proved* that some part is *non-solar*, while for the un- bted solar portion the term Chromosphere—the bright-line re- n—as it was defined in this theatre now two years ago, exactly resses its characteristic features, and differentiates it from the tosphere and the associated portion of the solar atmosphere.

Iere my discourse would end, if it were not incumbent on me to e how grateful I feel to Her Majesty's Government for giving he opportunity of going to the eclipse; to place on record the asure we all felt in being so closely associated in our work with distinguished American astronomers who from first to last ed us greatly; and to express our gratitude to all sorts of new nds whom we found wherever we went, and who welcomed ıs if they had know us from our childhood.

. *Shooting Stars of August 10th–11th.*—At Sherburne, N. Y., arty of six persons watched for the August meteors on the night the 10th–11th of the month. Between 11^h 40^m and 12^h, *forty- ht* were seen. In the next hour *one hundred and forty-three* e counted, and in the first eighteen minutes of the next hour, *ty-two.* By this time the moon was sensibly diminishing the nbers seen, and the party broke up.

'he latitude of the radiant was one and one-half degrees less n that of the nebula in Perseus. Its length was at least two rees, extending from a point 2° or 3° to the left of that star ɔne 8° or 10° to the right. A large part of the tracks near the iant could, however, be regarded as diverging from the portion he left of *Eta.* Nearly or quite seven-eighths of the meteors e judged to be conformable to the above line as a radiant.

H. A. N.

. *On a Meteor seen at Wilmington, N. C., July* 19; by Capt. S. Martin.—On Wednesday night, July 19th, between 8 and 9 ock, we were very much startled by a blaze of light, followed a hissing noise like fire roaring. Our first thought was that house was on fire, but, in a second, a large ball of fire came ing through the air, immediately over the house, from the south 'ard the north, and broke in the northern heavens, throwing off ee large stars of crimson fire. Almost a minute after, there ıe a loud report, as of a cannon, only followed by a roll too g for a gun and not quite long enough for thunder.

IV. Miscellaneous Scientific Intelligence.

1. *Deep Sea Dredging, under the direction of the Coast Survey.*—The U. S. Coast Survey Steamer F. R. Hassler, commander P. C. Johnson, U. S. N., now approaching completion at Wilmington, Del., will be dispatched as soon as ready to the coast of California for the survey for which she is designed.

Prof. Peirce, Superintendent of the Coast Survey, to make this long voyage by way of the Straits of Magellan as profitable as possible to science, has offered to Prof. Agassiz the direction of a scientific party to sail in her, and pursue during the voyage deep sea researches and investigations in natural history at the different points of stoppage. The party will consist of Prof. Agassiz as director (accompanied by Mrs. Agassiz), Ex-President Hill of Harvard College as physicist, Assist. L. F. Pourtales of the Coast Survey in charge of deep sea dredgings, Dr. Steindachner as icthyologist, Mr. Blake as draughtsman. Some of the officers of the ship have also qualified themselves to assist in various researches. The points at which the steamer will probably stop will be Bermuda, Trinidad, Rio Janeiro, Montevideo, the Falkland Islands, the Straits of Magellan, Juan Fernandez, the Gallapagos.

The ship is fitted out with a special view to deep sea soundings and dredgings, and will probably be ready for sea in the latter part of September.

2. *International Congress of Prehistoric Anthropology.*—The annual meeting of this Congress, instituted by the Italian men of science, will open at Bologna on the 1st of October next, and continue eight days. The payment of twelve francs, which may be sent to Professor Capellino at Bologna, will entitle any one to a card of membership and to all its publications. The special questions before the meeting are:

(1.) The age of Stone in Italy.

(2.) The caverns on the borders of the Mediterranean, and particularly those of Tuscany, compared with those of southern France.

(3.) The lake-dwellings of northern Italy.

(4.) Analogies between the "Terramarres" and the Kjœkkenmœdding.

(5.) Chronology of the first substitution of bronze for iron.

(6.) Craniological questions with reference to the several races which have peopled the different parts of Italy.—*Les Mondes*, xxiv, 672.

3. *Prof. Marsh's Rocky Mountain Expedition.*—A letter to one of the editors from Prof. Marsh, dated Fort Wallace, Kansas, July 25th, 1871, states that he has just returned from his preliminary trip, among the Saurians, and has in his large collections, obtained in Kansas during the last fortnight, some very interesting things, including various portions of the hind limbs of the Mosasaurs, and some more remains of the Pterodactyl found last season.

By the latest information from the party, they were at Salt Lake City, bound westward.

4. *British Association.*—The meeting for the current year at Edinburgh commenced on the 2nd of August. Sir William Thomson, the President, delivered his inaugural address in the Music Hall. The Emperor of Brazil occupied a chair on the President's right hand. The present was the third meeting at Edinburgh during the 40 years of the existence of the association.

The report of the treasurer shows that at the Liverpool meeting (1870) £852 were taken in annual subscriptions, £1,103 from associate's tickets, and £910 from ladies' tickets. The whole income of the year was a little over £5,239, or more than twenty-six thousand dollars.

5. *American Association.*—The meeting was opened at Indianapolis on the 16th of August. The address of Prof. T. Sterry Hunt, the retiring president, was delivered to a large audience in the evening. Besides other business of the morning session, Professor J. E. Hilgard, of the U. S. Coast Survey, chairman of a special committee appointed with reference to establishing an observatory at one of the highest points of the Pacific Road, reported that a memorial had been presented to Congress on the subject, and favorable action was hoped for at an early day.

The proceedings of the meeting have come too late to be further noticed in this number.

6. *American Naturalist.*—The press of the American Naturalist, at Salem, Mass., will issue, according to a recent announcement, a number containing abstracts of papers read at the meeting of the American Association at Indianapolis, and the address of Dr. Hunt, the retiring President.

OBITUARY.

EDWARD CLAPARÈDE.—One of the most industrious and learned of the younger zoologists of Europe, Edward Claparède, has lately (June, 1871) died at Sienna, at the age of 39. His memoirs, begun in 1857, have been issued with remarkable rapidity. His principal works consist of his monographs on the Infusoria and Annelids. In all his papers, his thorough physiological and anatomical training is perceptible, his details being always discussed in all their general bearing. Living in Geneva, and a pupil of Johannes Müller, he wrote with equal facility French and German: an admirable draughtsman, his many papers, which have appeared in the principal German and French scientific periodicals, are excellently illustrated and wonderfully accurate.

His qualities as an original and independent observer are best seen in his larger memoir on the Annelids of the Gulf of Naples, and his observations on the Anatomy and Embryology of the Invertebrates made on the coast of Normandy. His style was remarkably clear and his information very extensive, as is shown from his scientific reviews in the Archives de Genève. Thoroughly independent in his scientific opinions, he never allowed himself to be carried away by weight of authority, and no scientific charlatan protected by eminent names was allowed to pass current; his

reviews and criticisms were often sharp, but always just, and never personal. The Academy of Geneva, where he was Professor of Anatomy, will find it difficult to fill the place of one who, in spite of his failing health, showed an enthusiasm for his science rarely equalled. A. AG.

ALEXANDER KEITH JOHNSTON, the geographer, died at Edinburgh, on the 11th of July, aged sixty-eight.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. DR. ELLIS'S *Life of Sir Benjamin Thompson, Count Rumford*,* is written in the best taste as a literary production, and sets the character of this philosopher in its true light as an original genius and able investigator. The memoir opens with a happy parallel between Benjamin Franklin and Benjamin Thompson, "who were born within twelve miles of each other, under like straits, in humble homes; both of English lineage, of an ancestry and parentage yeomen on the soil on either continent, without dependence upon inherited means, or patronage, or even good fortune." Yet it appears they were never acquainted personally, although they were for thirty years contemporaries, of similar tastes and pursuits, and were intimate in friendship or correspondence with some of the same distinguished persons. Both labored in an unselfish spirit, and both succeeded in doing what has been for the good of a common humanity, "without distinction of class, and without a view to any personal ends of thrift or glory." If Franklin, whether by good fortune or a keener sense, attained a higher fame as a statesman, there can be no doubt that Thompson was more eminent in his scientific pursuits and attainments, and that is no small praise in view of all that Franklin did in science. As historians of science which is cosmopolitan, we can overlook, if we cannot wholly excuse, the course which misled Thompson to take up arms against his country, under circumstances of a highly irritating character which go far to excuse what we have reason to know he often regretted. Dr. Ellis has had access to numerous original sources of information, which have enabled him to correct many errors which had become traditional in the lives of Rumford, and to add a great number of items, both curious and instructive, showing the youth to have been father to the man. His skill with his pencil was early developed as a caricaturist, and in sketches, as well as in attempts at wood engraving, he showed considerable skill when he was not over fifteen years of age. His letters of enquiry, addressed at about the same age to his early friend Loammi Baldwin, touch on many subjects of a scientific nature, which few boys at that age are wont to trouble themselves with; this brief note, dated "Woburn, August, 1769," will serve as an example:—

* Memoir of Sir Benjamin Thompson, Count Rumford, with notices of his Daughter. By GEORGE E. ELLIS. Published in connection with an edition of his works, by the American Academy of Arts and Sciences, Boston. Published for the Academy by Claxton, Remsen, & Haffelfinger, Philadelphia. 680 pp. 8vo. 1871.

The Complete Works of Count Rumford. Vol. I. Boston: Published by the American Academy of Arts and Sciences. 493 pp. 8vo.

: Please to give the Nature, Essence, Beginning of Existeuce, and Rise of n General, with the whole Theory thereof, so as to be able to answer all ons relative thereto. Yours, BENJAMIN THOMPSON."

. Ellis copies from the old memorandum book of young Thompwhich has fortunately been preserved, a number of very curious rs; among them, "An Account of what expence I have been at rds getting an Electrical Machine." Commencing "1771, July 1, . brass wyer,' and giving item by item over 'iron wyer,' 'Pewter ake bullets,' 'Old brass,' '1 Book Brass Leaf,' 'Oil bottles,' 'Cop-Filings,' 'Silver Brons,' 'Shellac,' 'Laquer,' 'Varnishing brush,' ıa fortis,' &c., &c.," which is soon followed by "An Account ıat Work I have done towards Getting an Electrical Machine." ras then 17 years old, and had enjoyed no advantages of ation beyond the most elementary training of a rural school, : early efforts "towards getting an electrical machine," being a hadowing of the energy and personal attention which many s later aided him in his memorable researches upon heat, in h he so broadly laid down the doctrines sustained by most re-table original experiments, in anticipation of the Mechanical ry of Heat. Our readers will find Dr. Ellis's memoir of Rum-a most entertaining and instructive portraiture of this remark-person. It will not be forgotten that he was the originator founder of the Royal Institution of Great Britain, where Davy, day and Tyndal have found the chief theater of their memor-labors. It is fitting that the American Academy of Arts and ıces at Boston, as the custodian of his funds, specially en-ed to them to promote research in his chosen departments of *it* and *Heat*, should publish "The complete works of Count ıford." They will probably fill four volumes. B. S.

On the direction and force of the Wind, with the fall of Rain Snow at Wallingford, Conn., from observations made by iamin F. Harrison, M.D., and reduced by FRANCIS E. LOOMIS,)., Prof. of Physics and Industrial Mechanics, Cornell Uni-.ty. pp. 62. (From the Transactions of the Conn. Academy of and Sciences, Vol. II, 1871).—The observations discussed in paper were made at Wallingford, a town about twelve miles h of New Haven. The wind observations were made with a ecording apparatus similar in most respects to Osler's self-rding anemometer, and embrace a period of five years. The rvations were reduced separately for each hour of each month ıe year; and the results are graphically represented upon a e which exhibits in a very striking manner the diurnal changes ıe wind's direction. During six months of the year, viz: from ber to March, inclusive, this diurnal change is small, but dur-the other six months the diurnal change is very great, and is ; remarkable in May and August, when during the forenoon average wind blows almost directly from the north, and in the noon almost directly from the south. This remarkable change he average direction of the wind is traced to the changes of erature of the land and the neighboring water; and the cause

assigned seems adequate to account for all the facts at present known in this vicinity. It is much to be desired that a similar series of observations should be made at New Haven, for the purpose of developing still more precisely the laws which govern the diurnal and annual changes in the wind's direction.

The Wallingford observations also show the mean force of the wind, together with its diurnal and annual changes, but in a manner less satisfactory than they show its direction.

The same article furnishes the fall of rain and snow at Wallingford for a period of twelve years, from which it appears that the average annual precipitation at Wallingford is fifteen per cent greater than at New Haven.

The good judgment and perseverance of Dr. Harrison in making these observations are greatly to be commended, and we hope his example may be imitated by many other observers in our country. The results of such observations are not only important in their bearings upon questions of pure science, but they are intimately connected with the interests of every individual, with the prosperity of agriculture, and the security of commerce.

3. *Annual Report of the Board of Regents of the Smithsonian Institution*, showing the operations, expenditures and condition of the institution for the year 1869; 430 pp. 8vo. Washington, 1871. —Besides the report of the Secretary, this valuable volume contains the following memoirs, selected from various sources:—Life and works of Kepler, by M. Berthrand; Eulogy of Thomas Young, by Arago; Memoir of A. Bravais, by E. de Beaumont; Life and Scientific Labors of S. Marianini, by C. Matteucci; Chemistry of the Earth, by T. S. Hunt; Electrical Currents of the Earth by C. Matteucci; on the Phenomena of Flight in the Animal Kingdom, with many illustrations, by M. Marey; on the Northern Seas, by M. Babinet; Report of the Trans. Soc. Phys. and Nat. History of Geneva; Coronado's March in Search of the "Seven Cities of Cibola," and discussion of their probable location, by Gen. J. H. Simpson, U. S. A.; on the Social and Religious Condition of the Lower Races of Men, by Sir John Lubbock; on the Principles and Methods of Paleontology, by T. H. Huxley; Remarks on the "Casa gicantesca" of Yzamal in Yucatan, by Dr. A. Schott; Forests and their Climatic Influence, by M. Becquerel; on a Meteorite, from Washington Co., Wisconsin, by Dr. Fr. Brenndecke; Remarkable Forms of Hailstones in Georgia, by S. Abich; Eruption of the Volcano of Colima, by C. Sartorius.

4. *Elemente der Mineralogie*, von Dr. Carl Friedrich Naumann. 8th enlarged and improved edition, with 836 figures, 606 pp. 8vo. Leipzig, 1871 (W. Engelmann.)—Dr. Naumann's Elements of Mineralogy is the most prominent of recent German Mineralogical text-books. Its editions have followed one another rapidly, and the present is the eighth. It is a complete but condensed work, its descriptions being brief, and also its notices of localities and its mention of chemical composition. The figures of crystals are numerous and excellent.

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[THIRD SERIES.]

ART. XXXII.—*On the Connecticut River valley Glacier, and other examples of Glacier movement along the valleys of New England*; by JAMES D. DANA.

IN former papers* I have spoken of the existence of a Connecticut valley glacier in the Glacial era; understanding by the expression, as I have said, that the under part of the great continental glacier lying in the Connecticut valley-depression moved *in the direction of the valley*—either while the great glacier was at its maximum thickness and held on its southeasterly course, or after its partial decline.

I propose now to give more fully the evidence with regard to the Connecticut valley movement; and, further, to show that other large valleys of central and western New England had also, in the same sense, their valley-glaciers—that is, they determined the direction of the ice that lay within them.

The facts appealed to in support of the conclusions are partly of my own observation; but they are mostly drawn, for Massachusetts, from the Report on the Geology of the State by Dr. E. Hitchcock, who labored with much enthusiasm in this department of the science; for New Hampshire, from an unpublished map by Prof. C. H. Hitchcock, kindly furnished me by its author; for Vermont, from the Vermont Geological Report, which contains the numerous observations of Prof. C. B. Adams, Prof. C. H. Hitchcock, A. D. Hager and Zadock Thompson; for eastern New York, between New England and the Hudson river, from the volume of the New York Geological

* Manual of Geology, 1863, p. 544; This Journal, II, xxxv, 249, 1863; Trans. Connecticut Acad., ii, 45; This Journ., III, i, 1, and 125.

Reports by Wm. W. Mather, an assiduous laborer in this field of research.

We learn, first, from the scratches on the rocks *outside* of the larger valleys of New England—that is, over its higher lands—that the general course of the continental glacier covering New England was between S. 20° E. and S. 50° E. The true course, deduced from the magnetic, is here given, and so throughout the following pages.

On the high region of western Connecticut (1000 to 1200 feet above the sea), about Warren and Litchfield, the author found the courses of the scratches S. 29° E.; more to the west, east of Kent, on Kent mountain, S. 19° E.; to the south of Kent, about Newtown, S. 38° E. Percival observes that over this western part of Connecticut the direction of the transfer of drift was to the S.S.E. (probably meaning S. 20°–25° E.); and he cites as proof the distribution of blocks of limestone over Litchfield county from Canaan, and also of other rocks over the same and other counties. Mather gives for the direction in Litchfield county, Conn., near Norfolk, S. 20°–25° E., and Hitchcock, for that on Mt. Tom, the highest elevation near Litchfield, S. 17°–22° E.

West of the State of Connecticut, between it and the Hudson river in Dutchess county, not far west of Arthursville, I obtained for the course of scratches (which were common over the region) S. 24° E. Mather found in Putnam county (south of Dutchess), near Patterson, S. 17° E. to S. 22° E.; in Dutchess county, mostly between S. 15° E. and S. 30° E., but in some places S. 35° E.; and north of Dutchess county, in Columbia county (west of Massachusetts), mostly S. 18° E. to S. 30° E., with some on the mountain top east of Shaker Village and elsewhere in that vicinity, S. 45° E.

In the Taconic range, along the western boundary of Massachusetts, Dr. Hitchcock found the course of the scratches on the top of Mt. Everett (2600 feet above the sea) and on the adjoining Mt. Washington S. 18° E.; 15 miles farther north, on top of Tom Ball in Alford, 30 miles north of Mt. Washington, S. 43° E.; on the east slope of the Taconic ridge near Pittsfield (in same latitude nearly with the Shaker village above alluded to) and at Egremont, on the west slope, about S. 50° E.; a little south of the latter, on Lenox mountain, near the road from Richmond to Lenox, S. 38° E. Scratches observed by the writer on Mt. Everett trended S. 27° E.

Again Dr. H. obtained for the course in middle Granville, 20 miles west of the Connecticut, S. 38° E.; between Otis and Becket, 30 miles west of the Connecticut, and farther north in Windsor, about S.E. For eastern Massachusetts (that is, the part of the State east of the Connecticut), Dr. Hitchcock gives as the average direction S. 24° E. He obtained in Royalston, nearly 20 miles west of the Connecticut, S. 18° E. to S. 38° E.

On the higher land of Vermont, away mostly from river valleys, the course of the scratches, according to the Vermont Geological Report, is for the most part between S. 35° E. and S. 55° E. In southern Vermont, on the higher land of Windham, 15 miles west of the Connecticut, S. 40° E.; in Wilmington, S. 29° E and S. 39° E. (intersecting): in central Vermont, in West Hancock, S. 50° E.; in Ripton, S. 60° E. In the northern half of the State, on Camel's Hump, 4088 feet above the sea, S. 55° E.; on Mt. Mansfield, 4430 feet high, S. 55° E.; on Jay's Peak, north of the latter, S. 50° E.; in Stowe, in the valley east of Mt. Mansfield, S. 35° E. Judging from the map in the Vermont Geological Report, which gives some observations not registered in the text, the average course on the higher lands away from the valleys is about S. 50° E.; and the same is not far from the course for the higher lands of New Hampshire, according to Prof. C. H. Hitchcock's map.

The facts show plainly that on the higher lands, both east and west of the Connecticut, and even over the elevated ridges of the Green Mountain range through Vermont, Massachusetts and Connecticut, and also west of this range over the eastern borders of New York, the great continental glacier had a southeastward course; in the latitude of Connecticut, about S. 25° E., and to the northward, S. 35° E. to S. 55° E. With such a course the glacier moved over the elevated lands on the west of the Connecticut river and the elevated lands to the east of that river, keeping onward, with little variation in its main movement notwithstanding the ridges in its course, and following no doubt the general slope of the surface of New England.

But this being true of the movement of its main mass, other facts show that the bottom ice of the great glacier followed often the courses of the valleys beneath it.

1. First as to the *Connecticut river valley ice.* This valley, or great north and south depression of New England, has its termination, as I have elsewhere observed, at New Haven, the Connecticut river channel leaving the valley at Middletown, Conn., and taking thence a southeastward course to the Sound. In the following table, the courses of glacial scratches along the valley are given for comparison with the course of the valley. It commences with localities at the south.

1. Connecticut.	Courses.	Observers.
E. of New Haven bay,	S. 10°–16° W. many	J. D. D.
North of Meriden,	S.	J. D. D.
New Britain,	S. 15° W.	Percival.
Mt. Carmel, 7 m. N. of N. H.	S. 30° W.	W. B. Dwight.
Wadsworth's mountain,	Southwesterly	Mather.
2. Massachusetts.		
Granby, 7 m. E. of Conn. R.	South nearly	E. Hitchcock.
Mt. Tom,	South "	"
Mt. Holyoke,	South, S. a few degrees W.	"

MASSACHUSETTS.	Courses.	Observers.
Sunderland, E. side of Conn. R.	South nearly	E. Hitchcock.
Deerfield, S.E. part,	South "	"
Montague, E. side of Conn. R.	South "	"
Greenfield, W. " "	South "	"
Northfield, E. " "	South "	"
S. VERMONT.		
Vernon, for 2 m. W. side of Conn. R.	S.	C. H. Hitchc'k
Guilford, 5 m. W. of Conn. R.	S. 8° E.–S. 13° E.	C. B. Adams.
Brattleboro, for a great distance along C.R.	S. and S. 8° E.	C. B. A.
Dummerston, near Conn. R.	S.	C. H. H.
Putney,	S. 5°–12° W.	C. B. A.
Rockingham,	S. to S. 2° W.	C. H. H.
Norwich, 2 m. W. of village,	S.	C. H. H.
Norwich,	S. 15° E. and S. 39° E.	
Thetford, W. part of town,	S. 9° E.	C. H. H.
East Fairlee,	S. 6° E.	C. H. H.
Bradford,	S. 19°–30° E.	C. H. H.
"	S. 30° E.	C. B. A.
Newbury,	S. 12°–30° E.	C. B. A.
Waterford and Barnet,	S. 5° E. many; also S. 8° E.	

In New Hampshire, the courses of scratches, as represented on the map of the State by C. H. Hitchcock, referred to above, correspond very nearly with those of Vermont. According to it, scratches trending *west* of south occur in the river towns Chesterfield, Walpole, Hanover, Oxford, Haverhill, and still farther north, along the Passumpsic, in Monroe and towns adjoining it on the east.

Now the average course of the whole Connecticut river valley and of the Passumpsic valley, its true continuation northward, is about S. 9° W. But its different parts vary from this: that north of Massachusetts trending about S. 12° W.; that in Massachusetts, S. 6° W., but varying in the southern part to S. nearly; that in Connecticut from the Massachusetts line to Hartford, S. 3° W.; that from Hartford to New Haven, S. 18° W.; and the whole average for Connecticut, S. 15° W.

The table shows that the courses along the valley from New Haven to White River Junction or Norwich, Vt., are between S. 16° W. and S. 9° E., instead of between S. 30° E. and S. 50° E., like the scratches over the higher lands; and that, therefore, the average difference between the general course of the glacier and its course along the Connecticut valley is over 30°, that is, in the valley there are upward of thirty degrees more of westing.

In Connecticut, in which the average course of the valley is S. 15° W., the common course of the scratches is S. 15°–16° W.

In Massachusetts, in which the valley trends S. to S. 6° W., the scratches trend a few degrees west of south on Mts. Holyoke and Tom, or in part at least, as stated by Hitchcock; and as these are much the highest points in this part of the valley (their tops 1126 and 1211 feet above the sea level), they afford

consequently the best evidence of the average direction of the movement in that region.

In Vermont, where the course of the valley for the more southern half is S. 12° W., the scratches trend S. to S. 13° E. But north of White River Junction the course of the scratches varies between S. and S. 30° E., yet many scratches at the farthest point, near the mouth of the Passumpsic, are S. 5° E. to S. 8° E.

In the part of the Connecticut valley south of Vermont the scratches conform closely in direction to the trend of the valley, and are the only scratches; while to the north there is a general southerly course in the scratches of the Connecticut river valley, yet at the same time about 15° less of westing than in the average trend of this part of the river. Moreover, in this upper part of the valley there are often, besides the valley set of scratches, another set having the southeasterly course of the great glacier.

The width of the region bearing the north-and-south scratches of the valley is generally twenty to thirty miles, but sometimes more. Going east or west of this there is a change more or less gradual to the course of the great glacier, and often also other scratches conforming to its course occur. In Massachusetts, in Heath, 15 miles west of the Connecticut, the course of the scratches given by Hitchcock is south with some westing, and the same on Mt. Pocomptuck in this town, 1888 feet high; and in Rowe, 20 miles west of the river, the course is S. 2° W. In southern Vermont, in Halifax, west of Vernon, and 10 miles west of the Connecticut, the directions given by Hitchcock are mostly S. 12° W.; but also, in *West* Halifax, 15 miles from the Connecticut river, S. 53° E.; in Marlboro, north of Halifax, S. 20° E. on high land; and also, at another locality, two courses, S. 7° W. and S. 53° E., intersecting.

The facts show beyond question that *the abrading agent of the Connecticut valley moved mainly in the direction of the valley.* The less degree of conformity of direction between the scratches and the valley in its *upper* portion is what should be expected; and so also the intersecting southeasterly scratches of this portion, and also of the region on either side of it a little distant from the river.

2. *Upper Champlain Valley.* The main part of Lake Champlain is the region of a vast plain—though a plain of water—and little or no conformity to its direction in the course of the scratches on its borders could be expected. At Burlington the courses are S. 19° E. to S. 31° E.; in Shelburne, south of Burlington, S. 17° E. to S. 29° E.; which courses show apparently that some diverting effect was produced by the main ridge of the Green Mountains. But the southern prolongation of the lake from Addison, and even from Ferris, southward to White-

hall, a distance of 40 to 50 miles, is very narrow, and occupies a proper valley, and here the scratches are parallel mostly to the trend of the lake—which trend is nearly north and south, excepting for the southern part, where it is about 16° *west* of south (S. 16° W.). Along this more southern portion, in Benson, the course of the scratches, according to the Vermont Report, is S. 8° E., S. 12° W., S. 15° W.; and in Orwell, just north, S. 8° E., S. 12° W. Farther north, in Bridport, the course is S. 20° W.: in Addison, S. 17° W. and S. 13° E.; at Larrabee's Point, S. 4°–12° E.; at Crown Point in New York, opposite to Bridport, S. 2° E. on the west side, and S. 27° E. on the east. In Putnam, N. Y., west of Benson, according to Mather, S. 10°–15° W. The conformity of the course of the scratches to the trend of the valley in its southern half is very close; in its more northern part, where, opposite Addison and beyond, the lake is over two miles wide, scratches both of the valley course and of the general course of the glacier occur together. The divergence in all, from the S. 40°–55° E. of the higher lands of the State, is very wide.

3. *Lamoille River Valley and Winooski River Valley.* These rivers, in the northern half of Vermont, rise in the *eastern* part of the State and pass through the Green Mountains, the former north of Mt. Mansfield, the latter just north of Camel's Hump; in the case of each, the bottom of the valley where the river passes the line of these mountains is not far from 4000 feet below their summits. The course of each is about N. 15°–20° W. and S. 15°–20° E.

Along each of these valleys, the glacial scratches are closely parallel to its main trend, as shown and recognized by the Vermont geologists. It is strikingly exhibited on a map of the State accompanying the report. On the Lamoille there are the courses S. 55° E. to S. 85° E.: on the Winooski, the courses S. 60° E., S. 80° E., and even east-and-west in one case.

4. *Otter Creek Valley.* Otter Creek flows northward along the great valley in the southern half of Vermont, just west of the axis of the Green Mountains, passing by Rutland, Brandon, Salisbury, toward the southern end of the broader part of Lake Champlain. Its general course is about N. 15°–20° W. and S. 15°–20° E. The glacial scratches in the valley have the courses S., S. 12° E., S. 15° E., S. 20° E.

5. *Merrimack River Valley* (New Hampshire). The conformity between the courses of the scratches along this valley above Lowell and its trend is well shown on the map of New Hampshire by Prof. C. H. Hitchcock. The average trend of the valley is but a little east of south, and the same is true of the scratches.

We have thus evidence of the existence during some part of the era of ice not only of a glacier movement in New England

ong the Connecticut river valley, but also of one along the pper Champlain valley, the Lamoille valley, the Winooski alley, the Otter creek valley, and probably the Merrimack alley; and many of the courses of scratches observed in other arts of Vermont and New Hampshire have divergences from ie normal course of the great glacier, which are probably due the valley-depressions of the surface. Among these smaller alleys are perhaps those of the Queechee, Black, Middlebury id White rivers of Vermont and the Deerfield of Massachu-etts; for the existence of an *independent* glacier in each of iese valleys is recognized as probable by Prof. Hitchcock, on ie ground of the conformity between the direction of the :ratches and the valley, although the iceberg theory is adopted y him for all the rest, even the Lamoille, Winooski and Con-ecticut. The writer has elsewhere mentioned the evidence in ivor of a Hudson river glacier movement, and of another in ie Mohawk valley running easterly through central New York; id further, of one along the St. Lawrence valley, the scratches i it following its course according to the observations of Dr. awson.

The facts are sufficient to prove that examples of valley iovements of glacier ice must have been common over the ontinent in the Glacial era, or rather the rule for all the larger alleys. It is hence evident that no observations on glaciers e complete which do not take into account the surface features f the country. Prof. Hitchcock recognized the deflecting in-uence of the Connecticut and Lamoille valleys; but the de-ection, in his view, was that of icebergs. Besides the argu-ient against the iceberg hypothesis elsewhere presented, New ngland affords another in the fact that if there were, at the me, a submergence to the depth required to overcome the ostacles to a southeast movement offered by the southerly end of the mountains, there would still have been no south-isterly flow of waters over its surface, since no currents having iis course exist in the adjoining seas. And further, the neces-ty of helping out the iceberg theory by bringing in glaciers for ome of the smaller valleys, because icebergs could not be sup-osed to have worked their way along them to do the scratching, fords another strong argument against it.

The question now comes up, whether the scratches in the alleys were made in the Glacial era while the glacier was of uite or nearly its maximum thickness, or during the decline f the glacier, when its thickness was so diminished as to make ie ice of the valleys essentially independent glaciers.

With regard to the Connecticut valley ice, the following evi-ence appears to show that the movement took place while the ontinental glacier still had its continental, or at least its New ngland, movement. *a.* In Massachusetts and Connecticut the

only scratches in the valley are those trending south or *west* of south, and they are often very deep; even the tops of Mt. Tom and Mt. Holyoke have only these scratches. This uniformity seems to prove that the direction of movement thereby indicated characterized the ice of this part of the valley through *the whole of the Glacial period.*

b. Again, if a local glacier occupied the valley having a thickness of say one, two, or three thousand feet, or such as would lie below the level of the Green Mountain summits, the glacier would have had through its breadth a nearly southerly course corresponding to the trend of the valley, and in that case southerly scratches should have existed over the whole surface, even localities remote from the Connecticut river—*where they are not found.*

In another place I have supposed that the southeasterly course which occurs in the scratches to the west of the Connecticut river might have been a resultant between the tendency to a southerly movement down the valley, and that down the slope into the valley. But this was so only to a very small degree. For the ice, after passing over the valley, resumed on the east its southeastward scratching.

c. In the part of the Connecticut valley north of Massachusetts, the course of the scratches is not that of the valley, but differs 10° to 15° from it to the *eastward.* This greater easting shows that the southerly movement of the ice induced by the valley was modified by some force pressing it eastward, and this force could only have been that due to the movement of the general glacier. Hence it proves that the general glacier existed at the time in nearly or quite its full force.

We may conclude, therefore, that the valley ice of the Connecticut had through its southern half (across Massachusetts and Connecticut) its own independent southward motion, mostly unmodified, during the whole progress of the Glacial era. But along the more northern part of the valley, there were the modifications in the valley movement just pointed out, and also scratches made by the general glacier. If the southeasterly scratches (those of the general glacier) should be found to be the older of the two sets, we should infer that when they were made the general glacier was then the thickest; but the facts would not prove that the thickness had been so far diminished as to leave the Connecticut valley glacier wholly an independent one. Prof. Hitchcock has stated as his belief that the southwesterly scratches were the oldest, but admits that there is much doubt with regard to it.

This movement of the bottom of a glacier six or eight thousand feet thick along a different course from its main mass wherever it lies in great valleys, is a necessary result of mechanical law. It moves just as thick pitch poured over a slop-

: surface in which there are a few large groovings would ve, the mass following the general surface, and the portions the grooves nearly or quite the course of the grooves. The ckness of the ice that followed the course of the valley was at st 2000 feet; for the southerly scratches occur not only on : summits of Mt. Tom and Mt. Holyoke, but also on the top Mt. Pocomptuck in Heath, 15 miles west of the Connecticut, : height of which, as stated, is 1888 feet.

As to the Lamoille, Winooski and Otter creek valleys, the e is somewhat different; for if the movement of the ice in : valleys took place when the great glacier was in full force, vas a movement in each *up the valley.* The valleys are, how- :r, of gradual slope—that of Otter creek extremely gradual— l facts show that the ice is often moved up slopes many hun- ›ds of feet. Dr. A. S. Packard, Jr., mentions the occurrence fossils in the drift on Mt. Katahdin (Maine) at a height of)0 feet above the sea, which must have been brought from : low country to the north where such fossils are found in ›ce. As Dr. Packard observes, such facts show that icebergs re not the transporting agents.

[t is, however, possible that each of these three valleys had independent glacier during the melting of the ice. But if the great glacier must have been removed wholly out of the y of the valley glacier, so as to be no impediment to its ›vement down the valley; and it seems probable, from the all extent of these valleys, that by the time the general cier had got out of the way, the valley ice would also have stly disappeared. It is quite probable that a careful study the scratches along one or another of these valleys may :ide this interesting question.

[t seems to be a natural consequence of a gradual melting of : great glacier, that sooner or later parts of the ice should re become independent and taken independent movements. e should naturally look for this independence at least the large valley of the Connecticut river. A thinning the ice to 2000 feet would necessitate, it would seem, a valley ›vement southward. And yet, as has been observed, the dences of such a glacier movement do not exist—that is, the atches are confined to so narrow a band along the center of : Connecticut valley as to show that they were not made by independent Connecticut valley glacier. How then can we oncile the fact that the ice must have thinned down to 2000 t, 1000 feet, and so on, and yet had no movement as a sepa- e glacier? The explanation is this:—The melting of the ice ›k place in the early part of the Champlain era—an era of ›sidence for New England and a large part of the continent ›d therefore favorable to the melting); and this subsidence s greatest in New England to the north, having been at least

325 feet in the latitude of Burlington; nearly 150 feet near the northern boundary of Massachusetts, one hundred miles from the termination of the valley (the highest terrace on the river in Hinsdale, New Hampshire, being 159 feet above the river, according to the Vermont Report); and 45 to 50 feet at New Haven, the southern end of the Connecticut valley. Such a subsidence would have diminished the average slope of the whole valley about *one-and-a-half feet a mile.* For the southern half, from northern Massachusetts to Long Island Sound—100 miles—the slope, which now averages *two* feet a mile, would have been reduced to *one-and-one-tenth* of a foot a mile; and from Springfield down, which is 60 miles from the Sound, and the height of the water level only 64 feet above the Sound, making the average slope below about one foot a mile, and where the Champlain subsidence was at least 60 feet more than at New Haven on the Sound, there would have been no appreciable slope in the waters; the basin, as it is designated by Hitchcock, from Middletown in Connecticut to Holyoke in Massachusetts, would have been strictly a basin.* Under such circumstances the ice along the valley would have lost all motion. The same condition of rest would have belonged to the ice of other north-and-south valleys of as small rate of descent; but not necessarily to east-and-west valleys like the Lamoille and Winooski.

High up even the north-and-south valleys, where the slopes were not sensibly changed by such a subsidence, local glaciers might well have existed. Evidences of them in the region of the White Mountains have been pointed out by Dr. A. S. Packard, in an excellent memoir on the Glacial Phenomena of Labrador and Maine (94 pp. 4to), published in Volume I of the Memoirs of the Boston Society of Natural History (1867); also by Professor Agassiz, in the American Naturalist for November, 1870, who states that he observed the marks of local glaciers in the White Mountain region in the year 1847, soon after his arrival in this country.

In the foregoing pages the facts from the State of Maine have not been referred to. These are well discussed by Dr. Packard in the memoir just referred to, in which he recognizes and applies the principle discussed in this and the writer's former papers on the valley glaciers. He observes that of the eighty

* In order to deduce the amount of subsidence for any place on the river from the height of the highest terrace above the ordinary level of the river, it is necessary to deduct first the height of the lower flats. This would give for the amount at Hinsdale 138 feet, which is 88 to 93 greater than at New Haven; and for the amount at Springfield, where the highest terrace is 136 feet, it would give 115 feet, or 65 to 70 feet greater than at New Haven. Such calculations may be in error, and generally will give less than the actual amount, because the height of the terrace depends on the amount of *excavation* that has taken place since the land reached its present level; and this is in most cases less than the amount of elevation.

lities of scratches that have been noted in Maine, the tches in sixty-two have a southeasterly course: that the :heasterly course of the glacial grooves and striæ is espe- ly marked in the interior of the State on the high lands and mountains; but, approaching the coast, the evidence shows , the glaciers moved down the river valleys, and thus assumed ιore north-and-south course, and at times, owing to local ds in the depressions, were even deflected so as to flow in a ction a few degrees west of south. The facts in Maine are such as are general to New England.

'he same principle is recognized by Prof. N. S. Shaler in the ceedings of the Boston Society of Natural History, for 1870. er similar facts have been recently pointed out in States to west of New England. When the applications of the prin- e are studied out over the whole continent, we shall under- d better than we now do the sources of the varied move- ts in the great glacier.

: XXXIII.—*The Paragenesis and Derivation of Copper and ts associates on Lake Superior;* by RAPHAEL PUMPELLY.

II. *Paragenesis of the Minerals associated with Copper.*

o. 1. CAPEN VEIN.—This is apparently a true fissure vein. :curs in a compact and very tough melaphyr, which is :edingly chloritic near the vein. All the joints within a ınce of several yards from the vein are covered with a coat- $\frac{1}{16}$ to $\frac{1}{2}$ inch thick, of dark-green and bluish-green chlorite, ng a combined fibrous and foliated structure oblique to the ; surfaces. The melaphyr is rich in magnetite. Sheet cop- was found in mining, but not in paying quantity.

Laumontite, in thin seams.

Prehnite, in seams which cut through those of laumontite, between symmetrically arranged bands of laumontite.

Chlorite, as destroyer and replacer of prehnite, and as ıg of cavities in the latter.

Analcite, in clear crystals on the prehnite and chlorite.

Calcite.

o. 2. HURON MINE.—1. *Laumontite*, in thin crystalline ls on the sides of a cavity; the free ends of the opposed tals nearly meet.

Prehnite, filling the space between the bands of laumontite.

o. 3.* COPPER FALLS MINE.—Fissure vein. 1. (?) *Natro-* 2. *Laumontite.* 3. *Analcite.*

o. 4.* SAME VEIN.—1. *Apophyllite.* 2. *Copper.* 3. *Orthoclase.*

*aken from a list given by Hilary Bauerman, Quart. Journ. Geol. Society, 1866.

No. 5.* BAY STATE MINE.—1. *Prehnite.* 2. *Quartz.* 3. *Copper.* 4. (?) *Laumontite.*

No. 6.* PHŒNIX MINE.—Fissure vein. 1. *Laumontite.* 2. *Quartz.* 3. "*Green-Earth.*"

No. 7.* BAY STATE MINE.—Fissure vein. 1. *Quartz.* 2. *Apophyllite.* 3. *Calcite.*

No. 8.* BOHEMIAN MINE.—1. *Analcite.* 2. *Copper.* 3. *Orthoclase.*

No. 9. AMYGDALOID MINE.—Fissure vein. 1. *Prehnite*, in its characteristic reniform shape.

2. *Quartz*, in small crystals on the prehnite.

3. *Analcite* crystals, covering the quartz.

4. *Orthoclase* crystals, on the analcite and quartz.

No. 10. BAY STATE MINE.—Fissure vein. On the soft brown gangue. 1. *Analcite*, lining part of a vugg. The crystals are ¼ inch in diameter, often white and transparent, but very much fractured. Near the contact with the rock they are often reddened internally and much altered, and then surmounted by the next member.

2. *Orthoclase*, in the usual minute crystals, some of which are scattered over the altered analcites.

No. 11. AMYGDALOID MINE.—Fissure vein. 1. *Prehnite*, in the characteristic reniform shape, forming the body of the specimen; fresh-looking on the free surface, but on the under broken side somewhat porous, with earthy fracture, and then rather intimately associated with datolite and a soft green (chloritic ?) mineral.

2. *Copper*, in films traversing the prehnite, and molded to the reniform surface. While the under surface of the copper bears the impression of the prehnite, the upper surface, now free, bears that of some mineral that is gone; threads of copper rising from this free surface ½ inch are crystallized at the tips, where they stood above the mineral that has disappeared.

3. Minute grains of a hard yellowish-white mineral, sprinkled like meal over the prehnite and copper; under the microscope appear to consist of sheaf-like clusters of minute rhomboidal plates; fuses with difficulty.

4. *Datolite*, in microscopic crystals on No. 3; others, one line in diameter, rosy, with suspended flakes of copper, lie upon the prehnite.

No. 12. AMYGDALOID MINE.—(Fissure vein.) On the gangue—here chloritic—lie, 1. *Calcite*, imbedded between the gangue and No. 2.

2. *Prehnite*, forming the greater part of the specimen, and having a tolerably fresh luster.

3. *Copper*, in grains, flakes and threads conforming to the radiating cleavage planes of the prehnite.

4. *Datolite;* compact amorphous, white translucent mass, covering the prehnite with a layer of which $\frac{1}{8}$ inch thickness, still remains. The copper threads do not penetrate it.

No. 13. PEWABIC COPPER-BEARING BED.—This specimen—about $2\frac{1}{2}$ inches by $3\frac{1}{2}$ by $\frac{3}{4}$—is evidently from the interior of a druse, to whose wall it was attached by only a small part of its surface. The body of the specimen is copper, very cavernous, much of it pseudomorphous after laumontite. The copper is very thickly bestrewn with small green crystals of quartz—prisms terminated at both ends,—which are however *older* than the copper. On the sides and around the edges of the specimen there are beautifully modified scalenohedrons of calcite. The successions are:

1. *The rock or mineral* to which the laumontite was originally attached, and which has disappeared.

2. *Laumontite* or leonhardite; has also disappeared; the prisms were $\frac{1}{4}$ to $\frac{1}{2}$ inch long, terminated at one end with a hemi-dome.

3. *A mineral*, now gone, which must have been present to support the quartz crystals (see Quartz). It may perhaps have been the alteration-product of the laumontite or an enclosing mineral; laumontite crystals occur frequently enveloped, except the base, in calcite.

4. *Quartz*, in prisms $\frac{1}{16}$ to $\frac{1}{4}$ inch long, often terminated at both ends. They occur on parts of nearly every one of the pseudomorphs after laumontite; the copper is moulded to them, giving casts even of the striæ on the prisms, and they frequently pass entirely through the pseudomorphs after laumontite, so that the two ends of a quartz prism frequently just appear on opposite sides of the pseudomorph and transmit light. In some instances the quartz crystals are so numerous as to touch each other, but they are often wholly isolated, and supported only by the copper which is younger.

The quartz crystals contain minute, brilliant particles of copper, wholly isolated, in the interior.

5. *Copper*, in the form of laumontite, preserving often the sharpness of the angles and smoothness of the faces of the original mineral, when seen by the naked eye; under the glass the surface is less even. The pseudomorphs are not solid copper, as will appear in describing other specimens.

6. *Chlorite?* a soft, light-green mineral in minute hemispherical forms, with radiating structure, scattered over the quartz and copper. Wherever this mineral lies upon the quartz crystals, these are more or less penetrated by it, and some of them are eaten through and through to such an extent that the crystalline form is no longer recognizable.

7. 2*d Copper Calcite;* Calcite crystals—scalenohedrons—$\frac{1}{4}$ to $\frac{3}{4}$ inch long, lie on the sides and around the edges of the specimen. These crystals, in forming, adapted themselves with partially entering faces to the rough surface of the preëxisting quartz and copper. Some of the calcite crystals contain brilliant isolated films of copper, which must have been formed at least after the calcite had begun to crystallize, and is therefore younger than the copper previously mentioned.

8. *Datolite*, in exceedingly minute crystals, lying on both the chlorite and calcite; they are less than $\frac{1}{500}$ inch in diameter, but the datolite form is distinctly visible under the microscope; they fuse easily with the characteristic green flame.

No. 14. PEWABIC COPPER-BEARING BED.—1. *The rock* or mineral to which the laumontite was originally attached, which has disappeared, copper now forming the support of all the members.

2. *Laumontite*, of which only the form now remains.

3. *A mineral*, now gone, which seems necessarily to have been present to support the isolated crystals of quartz.

4. *Quartz*, in minute prisms, containing brilliant particles of copper.

5. ? *Calcite*, represented only by impressions in the copper. This calcite may, perhaps, be older than some of the foregoing members.

6. *Copper*, now forming the body of the specimen. It is very cavernous, and besides forming in places pseudomorphs after laumontite, it is the support of every member of the series. That it is younger than the quartz crystals is shown by the fact that on removing these, perfect casts of them are visible in the copper. The copper also contains impressions of calcite crystals (see above).

7. *Chlorite?* the same mineral as the 6th member of No. 13, and occurring in the same manner.

8. *Calcite;* a few small scalenohedrons planted on the copper in the impressions of the older calcite = 5th above.

No. 14*a*. *Copper after laumontite*, from the PEWABIC COPPER-BEARING BED.

The upper face of this specimen is part of a partially filled cavity in a cupriferous and highly altered amygdaloid; the lower, or broken face, is a portion of the altered amygdaloid itself. The general appearance of the specimen at first glance is that of a drusy cavity, nearly filled, except in the middle, with broken crystals of calcite, whose interiors contain many thin plates and threads of native copper.

The amygdaloid is a soft compact brown and green rock with earthy fracture,—an altered amygdaloidal melaphyr. The small amygdules near the wall of the larger cavity are of calcite.

The pseudomorphs of copper after laumontite are prisms $\frac{1}{8}$ to $\frac{1}{2}$ nch long and about $\frac{1}{8}$ of an inch square, and are terminated vith a hemidome; they are each attached by one end to the vall of the cavity and project out toward the interior. The ngles are often sharp, though in some instances the junction of wo faces of a prism presents something of the appearance of a opper cast made in a mould whose two halves fit only imperectly together. Sometimes, under a strong glass, the joining is learly imperfect, and the pseudomorph has the effect of a prism uilt with four badly-soldered plates of metal.

Minute prisms of quartz (colored green by the chlorite-like nineral mentioned in specimens No. 13 and 14) project from he interior of the pseudomorphs, through the copper, to $\frac{1}{100}$ of n inch above the surface.

In one place I cut to the depth of $\frac{1}{12}$ of an inch in solid copver; but a cross fracture in another prism showed that the opper was, there, a mere superficial film, while the interior was ccupied by a confused and rather porous mass of quartz risms, copper, and the green chlorite-like mineral mentioned bove. It is these quartz crystals whose ends just pierce the opper coating. In some instances a prism of quartz terminated t both ends passes entirely through the pseudomorph and ppears on both sides, and allows the light to pass through. fter removing a quartz crystal from the copper, a perfect cast, ven to the horizontal prism-striæ is found in the copper.

The copper-surface of the pseudomorphs seems nearly smooth o the naked eye, but under a strong glass it appears not only ften perforated with holes, but it often shows flakes of copper ising on edge to a height of $\frac{1}{100}$ of an inch above the face.

These pseudomorphs before the breaking of the specimen vere imbedded in the interior of scalenohedrons of calcite, xcept at the attached ends of the prisms. At the contact planes etween the calcite and the pseudomorphs, the former seems to dapt itself fully to all the irregularities of surface of the latter.

On the bottom of the specimen the calcite amygdules exhibit narked signs of change to datolite. The transparent crystals ecome gradually opaque, with a pearly lustre on the cleavage lanes, and a little farther away this condition merges almost nsensibly into a lustreless white mass composed of an aggregaion of exceedingly minute crystals, which exhibit the datolite orm under the microscope, and fuse easily with the characterisic green flame before the blowpipe. The same change is isible, in places, on the crystals of calcite enveloping the seudomorphs after laumontite.

The relative ages here appear to be, 1, *The amygdaloid*, hough probably not in its present condition; 2, *Laumontite*; , *Quartz*; 4, *Copper*, *chlorite-like mineral*; 5, *Calcite*; 6, *Datolite*.

No. 14 (*b*) *Another specimen* from the same locality exhibits, —besides pseudomorphs of copper after laumontite,—pseudomorphs of quartz after laumontite. In these last, the ends of the pseudomorphs are broken off, leaving only the prism. The faces are formed by a tolerably even mass of quartz, on the outer surface of which a crystalline form appears here and there under the glass. The interior of the prism is not a compact mass of quartz, but is nearly filled with quartz prisms projecting from all sides toward the middle and containing minute brilliant and isolated particles of copper.

Near these are the copper pseudomorphs; they are mere hollow shells, scarcely as thick as paper; the angles are sharp and the faces tolerably smooth, but often pierced with holes. The hemidome of one of these is studded with the ends of minute quartz prisms, which occupy the interior of that part of the pseudomorph and project through the copper shell.

In this specimen also, some of the pseudomorphs are imbedded in scalenohedrons of calcite, which sparkle with brilliant particles of copper swimming in the transparent crystals.

In these remarkable pseudomorphs the quartz is undoubtedly the oldest existing intruder, while the copper, which far more generally preserves the crystalline form of the laumontite, seems to be pseudomorphous in, at least, the second degree of removal. Yet in nearly all instances the older quartz is present, occupying a part of the space originally belonging to the laumontite crystal; and very often these quartz crystals are wholly separate from each other and supported only by the younger copper. Something which is now gone must have existed to perform this office of support before the copper was deposited.

No. 15. "RAGGED AMYGDALOID," ALBANY AND BOSTON M.—On the rock lie: 1, *Prehnite*—2, *Orthoclase*, in minute crystals on the prehnite.

No. 16. "EPIDOTE LODE," ST. MARY'S.—In a cavity in the quartz-epidote rock, which forms a frequent feature of this bed, lie: 1, *Prehnite* crystals, disposed as a reniform lining of the cavity—2, *Quartz*, in transparent prisms on the prehnite—3, *Analcite*, crystal ½ inch in diameter, slightly opaque and somewhat cavernous internally, planted on the quartz.

4. *Orthoclase* crystals planted on the prehnite, quartz and analcite.

The prehnite is partially altered, containing cavities lined or filled with a soft green mineral, chlorite or green-earth. There is also a greenish-yellow chlorite-like mineral, which incrusts and has eaten away the surface of the quartz crystals.

No. 17. AMYGDALOID ON THE KEARSARGE LOCATION.—On the rock lie: 1, *Prehnite*—2, *Quartz* on the prehnite.

No. 18. Huron Mine.—On the rock lie: 1, *Analcite*, in a continuous band ¼ inch thick, crystallized on the inner face; it is reddish and perhaps much altered, though still hard—2, *Calcite* incrusting the analcite crystals, and occupying cavities in their interior.

No. 19. Albany and Boston Amygdaloid.—The rock of this bed is a wholly irregular mixture of hard light-green amygdaloid and soft brown amygdaloid, in which the vesicular form is frequently lost from the fact that the cavities containing secondary minerals have extended and become merged together, forming a confused patch and vein structure: 1, *Prehnite*, amorphous and altered to a slightly cavernous appearance on the surface—2, *Quartz* in prisms—3, *Orthoclase* in minute crystals chiefly on the altered prehnite, with which its formation is probably connected, and also on the quartz.

No. 20. Same bed.—On the amygdaloid, which contains quartz amygdules, lie: 1, *Prehnite* penetrated with strings and films of copper—2, *Quartz* in prisms; *chlorite-like mineral* in hemispherical forms, with radiating structure—*Orthoclase* in minute crystals; all these lie separately on the prehnite—3d, *Calcite* covering all the above mentioned members.

No. 21. Same bed.—1, *Quartz*, in prisms—2, *Chlorite-like mineral* in hemispherical forms, with radiating structure; wherever it is in contact with the quartz it has pitted it and eaten into it—3d, *Calcite*.

No. 22. Same bed.—On the amygdaloid lie:—1, *Prehnite* crystals in reniform masses—2, *Quartz*, in prisms on the prehnite crystals—3, *Orthoclase; Calcite;* the orthoclase is in minute crystals on the prehnite and quartz.

No. 23. Same bed.—The amygdaloid on which the following succession occurs consists of quartz and chlorite, and is wholly altered—so much so that the quartz which now composes a large part of it is evidently of the same age as that which follows the prehnite—1, *Prehnite*, in crystalline reniform masses —2, *Quartz* prisms—3, *Copper* in cubes, with octahedral modifications, planted on, and moulded to, the quartz crystals.

No. 24. Same bed.—1, *Prehnite*—2, *Quartz*—3, *Calcite*.

No. 25. Same bed.—1, *Analcite* in pellucid crystals—2, *Calcite; Orthoclase;* in this specimen the analcite appears to have incrusted some mineral which has disappeared, and the feldspar crystals occur in the cavity thus formed as well as on the outer surface of the analcite.

No. 26. Same bed.—1, *Prehnite*—2, *Quartz*—3, *Copper*, in threads often moulded to the quartz—4, *Orthoclase* in minute crystals planted on the prehnite, quartz and copper.

No. 27. Same bed.—1, *Prehnite*, penetrated with copper threads—2, *Quartz* in prisms—3, *Chlorite-like mineral* mentioned in Nos. 20 and 21; here also it has eaten into the faces of the quartz crystals—4, *Analcite* crystals, much fractured and eaten away, and sometimes quite hollow.

No. 28. Same bed.—1, *Prehnite* in places cavernous—2, *Quartz* in prisms in the cavities in the altered prehnite—3, *Orthoclase* crystals planted on the quartz.

No. 29. Same bed.—1, *Prehnite*—2, *Copper* traversing the prehnite in the form of threads, etc., ending in crystals which adapt themselves to the crystalline surface of the prehnite.

No. 30. Same bed.—1, *Prehnite*—2, *Analcite*—3, *Copper*, in flakes on the analcite—4, *Orthoclase; chlorite-like mineral.*

No. 31. Same bed.—1, *Quartz* in prisms—2, *Orthoclase* crystals, planted on the quartz.

No. 32. Same bed.—1, *Prehnite*—2, *Copper* in crystals whose under surfaces are moulded to the crystalline surface of the prehnite.

No. 33. Huron Mine.—On the amygdaloid containing smaller amygdules of delessite and quartz, lie:—1, *Laumontite*, a crystalline layer with projecting crystals—2, *Calcite* crystalized upon and wholly enveloping the laumontite crystals.

No. 34. Westernmost Adit on the "Southside." 1. *Analcite*, in opaque crystals $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. 2. *Orthoclase* crystals planted on the analcite. (The rock containing this is chocolate-brown, and filled with small amygdules of 1st Laumontite, 2d Calcite).

No. 35. "Ragged Amygdaloid." St. Mary's. This is a soft brown amygdaloid with brown streak, in which the cavities have assumed the most irregular shapes and merge into each other in a manner which gives to the rock a highly brecciated appearance. The cavities are generally partially open at their wider points; and the minerals occupying them are chiefly the following, often accompanied by a white clay. On the rock lie, 1. *Analcite.* 2. *Orthoclase* crystals on the analcite. 3. *Calcite* over both the foregoing members.

No. 36. Same bed. On the rock lies *Calcite. Orthoclase* crystals on the calcite.

No. 37. Same bed. On the rock are scattered, 1. *Analcite* crystals. 2. *Calcite* on the analcite.

No. 38. Same bed. 1. *Analcite* in large crystals; much altered. 2. *Orthoclase* crystals planted upon the outer surface of, and in cavities in, the analcite.

No. 39. Pewabic Copper-bearing bed. On the amygdaloidal rock lies, 1, *Calcite; copper.* 2. *Datolite* in a granular mass incrusting the calcite crystals.

No. 40. Same bed? 1. *Calcite* in scalenohedrons. 2. *Datolite*, a granular mass of microscopical crystals. Here the datolite has partially displaced the calcite; only the points of the crystals of the latter were exposed, all the rest being embedded in the younger datolite. These free-standing points remain perfect in glance and form, while wherever the calcite crystals are in contact with the datolite, their surfaces are roughened and perceptibly eaten into. The calcite crystals rest upon a granular mass of the same variety of datolite, which is perhaps the result of a displacement of calcite.

No. 41. "Evergreen Bluff." 1. *Quartz* prism. 2. *Orthoclase* in minute crystals. 3. *Calcite* in simple and twin scalenohedrons.

No. 42. "Amygdaloid" Mine. (Fissure vein). 1. *Copper.* 2. *Compact datolite.*

No. 43. Same Vein. 1. *Prehnite* in its characteristic form. 2. *Copper* conforming to the radiating cleavage-structure of the prehnite. 3. *Datolite*, compact.

No. 44. Locality Unknown. 1. *Prehnite* in its characteristic form. 2. *Quartz* in prisms on the prehnite. 3. *Analcite* crystals on the quartz. 4. *Orthoclase* crystals on the analcite.

No. 45. Westernmost Adit. "Southside." Small amygdules consist of, 1. *Laumontite.* 2. *Quartz* surrounded by the laumontite.

No. 46. Michigan Mine (Fissure vein). On the veinstone, which is here a greenish-gray, hardened clay-like material with flakes of chlorite and copper, and which becomes brown and soft near the contact with No. 1, lies, 1. *Datolite* in a uniformly distributed layer $\frac{1}{16}$ of a line to 2 lines thick, with the free surface highly crystallized. The crystals are transparent and rose-colored from the presence of minute particles of copper. The datolite appears quite fresh, and the copper seems to be confined to it. 2. *Calcite*, four small slightly yellowish semi-transparent rhombohedrons, modified with steeper scalenohedron faces, lie upon the datolite. 3. *Orthoclase*, yellowish crystals, $\frac{1}{20}$ of an inch long, are scattered over the surface of the specimen, some lying upon the calcite and some upon the datolite.

No. 47. Many localities. 1. *Prehnite.* 2. *Delessite.* The prehnite which occurs as the solid filling of amygdaloidal cavities in the upper part of many beds, is subject to alteration to chlorite. It is very common to see the prehnite soft and green to a slight depth from the outer surface of the amygdule, without any line of separation between this portion and the hard center; and in the interior the prehnite often passes gradually into spots and flakes of chlorite. In these amygdules the prehnite is characterized by a radiating structure, starting from

a single center. It is along these planes of radiation that the change begins. Every possible gradation is observable. The resulting product is sometimes a mass of foliated chlorite, but more generally it is an amygdule of compact chlorite, exhibiting in its fracture the same radiating structure as the prehnite.

No. 48. SHELDEN AND COLUMBIAN LOCATION. 1. *Prehnite* which is the general filling of the cavities in the upper part of the amygdaloid of this locality. 2. *Feldspar*, red. It is quite an exceptional occurrence in this neighborhood, and it is intimately associated with the prehnite in a manner that makes it seem to be pseudomorphous after it.

Crystals of epidote and of quartz occur on this feldspar, but the specimen gives no insight into their relation, as regard age, either to each other or to the feldspar as a secondary product.

No. 49. SOUTH PEWABIC MINE. In this bed a frequent form of the rock is a compact amygdaloid, of which 50 or 60 per cent of the volume consists of amygdules from the size of a pin-head to ⅛ inch in diameter. The matrix in a specimen before me is brown, and too hard to be scratched with a knife. The amygdules are sometimes of calcite, but more generally contain, 1. *Quartz*, clear and filling the cavity. 2. *Chlorite; copper.* The chlorite (apparently delessite) appears to displace the quartz; in some amygdules it merely penetrates the fissures of the quartz, giving to this a green color; in others nothing remains but a cavernous mass of quartz and chlorite usually well charged with copper; indeed the copper occurs here only with this chlorite.

The series to which this bed belongs is represented on the "Southside," and again on the St. Mary's, by amygdaloids which resemble this one in all essential particulars, except that the amygdules are there filled chiefly with laumontite, and are free from copper and nearly free from chlorite.

No. 50. "OSSIPEE AMYGDALOID." The rock is compact, spotted green and brown, and contains small *separate* amygdules of prehnite, quartz, epidote, calcite, chlorite. The chlorite appears as a destroyer of prehnite, quartz and calcite. A larger cavity shows the following succession: 1. *Prehnite;* a lining ⅛ to ⅛ inch thick, much altered and in places changed to chlorite. 2. *Orthoclase*, minute crystal. 3. *Epidote* on the feldspar.

No. 51. HURON MINE. In places, the Isle Royale copper-bearing bed consists largely of a light grayish-green, fine-grained rock of epidote and chlorite indurated with quartz; small, irregular cavities in this contain, 1. *Epidote;* crystalline lining ½ inch thick. 2. *Quartz* filling the interior.

. SHELDEN AND COLUMBIAN MINE. In cavities in a
ad green amygdaloid lie, 1. *Quartz* in well shaped
2. *Calcite; Quartz.* This second quartz is in small
much distorted crystals, which are often partially im-
a the calcite, and are also often planted on the older
om which they can be easily removed without fracture.
. HURON MINE. 1. *Quartz* with more or less crys-
ructure. 2. *Copper* moulded on the quartz and filling
id interstices in it.
. RAGGED AMYGDALOID. ST. MARY'S. In the rock
35), some of the smaller cavities contain, 1. *Orthoclase*
crystalline lining. 2. *Calcite* filling the interior. 3.
ke mineral penetrating and apparently replacing the

rger cavity occur the following:
. 1. *Analcite* crystals ½ inch to 2 inches in diameter,
ldened. 2. *Orthoclase;* small crystals on the analcite.
a soft white mineral, apparently the result of con-
composition of the analcite under conditions unfavor-
he formation of new silicates as feldspar.
3. "ANCIENT PIT" BED. DOUGLASS LOCATION. 1.
orming a crystalline lining of a cavity. 2. *Quartz*
e interior.
. SULPHURET (Fissure vein) HURON LOCATION. The
3 inches wide) consists of the following: 1. *Ankerite?*
ne, massive, white on fresh surface, but rusty-brown
ed fractures) forming the member nearest the wall on
. 2. *Quartz* in two symmetrical comby bands on the
and in thin seams in the dolomite connected by cross-
th the quartz-comb. 3. *Chalcocite*, black—bluish-black
nct cleavage. It resembles the pseudomorphous chalco-
e Lac la Belle mine. Bornite occurs sprinkled through
ocite in minute specks; in places it predominates,
s to the exclusion of the latter.
sulphurets form the central member, and bunches of
often surrounded by the older members, giving the
" structure to the vein.

is in another portion of this vein that the arseniurets, whitneyite and
are found.

attempted to bring the foregoing observations into
ving tabular form for greater convenience of compari-
e table is unavoidably imperfect, owing to the necessary
s which arise in attempting to compare the successions
ent localities. The detailed observations, however,
e for a check upon the imperfections of the schedule.
R AND CALCITE.—In many of the instances in which
rystals are found enclosing copper, it is difficult and

Capen Vein, ------	1	Laumontite	-----	Prehnite	-----	---	-----	Chlorite	Analcite	Calcite	----	----	------	----
Huron Mine, ------	2	Laumontite	-----	Prehnite	-----	---	-----	-------	------	---	----	----	------	----
Copper Falls Mine,* ---	3	Laumontite	-----	------	-----	---	-----	-------	Analcite	---	----	----	------	----
" " " * ---	4	------	-----	------	-----	---	-----	-------	Apophyllite	---	Copper	----	Orthoclase	----
Bay State Mine,* ------	5	------	-----	Prehnite	Quartz	---	Copper	-------	------	---	----	----	------	----
Phœnix Mine,* ------	6	Laumontite	-----	------	Quartz	--	-----	Green-earth.	------	---	----	----	------	----
Bay State Mine,* ------	7	------	-----	------	Quartz	---	-----	-------	Apophyllite	Calcite	----	----	------	----
Bohemian Mine,* ------	8	------	-----	------	-----	---	-----	-------	Analcite	---	Copper	----	Orthoclase	----
Amygdaloid Mine, ----	9	------	-----	Prehnite	Quartz	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Bay State Mine, ------	10	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Amygdaloid Mine, ----	11	------	-----	Prehnite,Cu	-----	---	-----	-------	------	---	----	Datolite	------	----
" " ----	12	------	Calcite	Prehnite,Cu	-----	---	-----	-------	------	---	----	Datolite	------	----
Pewabic Lode, -------	13	Laumontite	-----	------	Quartz	---	Copper	Chlorite or Green-earth.	------	Calcite. Copper.	----	Datolite	------	----
" " ------	14	Laumontite	-----	------	Quartz	Calcite	Copper	Chlorite or Green-earth.	------	Calcite	----	----	Orthoclase	----
Alb. and Bost. "Ragged Amygd." -----	15	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Orthoclase	----
"Epidote Lode," St. Mary's, ----------	16	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	Analcite	---	----	----	------	----
Amygd. Kearsarge, ---	17	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	------	----
Huron Mine, ---------	18	------	-----	------	-----	---	-----	-------	Analcite	Calcite	----	----	------	----
Alb. & Bost. Amygd. --	19	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
" " " --	20	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	------	---	----	----	Orthoclase	Calcite
" " " --	21	------	-----	------	Quartz	---	-----	Chlorite or Green-earth.	------	---	----	----	------	Calcite
" " " --	22	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
" " " --	23	------	-----	Prehnite	Quartz, Cu	---	-----	-------	------	---	----	----	------	----
" " " --	24	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	------	Calcite
" " " --	25	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Calcite. Orthoclase.	----
" " " --	26	------	-----	Prehnite	Quartz, Cu	---	-----	-------	------	---	----	----	Orthoclase	----
" " " --	27	------	-----	Prehnite	Quartz	---	-----	Chlorite or Green-earth.	Analcite	---	----	----	------	----
" " " --	28	------	-----	Prehnite	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
" " " --	29	------	-----	Prehnite,Cu	-----	---	-----	-------	------	---	----	----	------	----

													Orthoclase.	
" " "	31	------	-----	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
" " "	32	------	-----	Prehnite, Cu	-----	---	-----	-------	------	---	----	----	------	----
Huron Mine,	33	Laumontite	Calcite	------	-----	---	-----	-------	------	---	----	----	------	----
"Southside,"	34	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
"	"	Laumontite	Calcite	------	-----	---	-----	-------	------	---	----	----	------	----
"Ragged Amygdaloid,"	35	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	Calcite
" "	36	------	-----	------	-----	---	-----	-------	------	Calcite	----	----	Orthoclase	----
" "	37	------	-----	------	-----	---	-----	-------	Analcite	Calcite	----	----	------	----
" "	38	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	Orthoclase	----
Pewabic Bed,	39	------	-----	------	-----	---	-----	-------	------	Calcite	Copper	Datolite	------	----
" "	40	------	-----	------	-----	---	-----	-------	------	Calcite	----	Datolite	------	----
Evergreen Bluff,	41	------	-----	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	Calcite
Amygdaloid Mine,	42	------	-----	------	-----	---	-----	-------	------	---	Copper	Datolite	------	----
" "	43	------	-----	Prehnite	-----	---	-----	-------	------	---	Copper	Datolite	------	----
Unknown locality,	44	------	-----	Prehnite	Quartz	---	-----	-------	Analcite	---	----	----	Orthoclase	----
"Southside,"	45	Laumontite	-----	------	Quartz	---	-----	-------	------	---	----	----	------	----
Michigan Mine,	46	------	-----	------	-----	---	-----	-------	------	---	Datolite	Calcite	Orthoclase	----
Many localities,	47	------	-----	Prehnite	-----	Delessite		-------	------	---	----	----	------	----
Shelden & Columbian,	48	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Feldspar	----
South Pewabic Mine,	49	------	-----	------	Quartz	--	-----	Chlorite or Green-earth. Copper.	------	---	----	----	------	----
Ossipee Amygdaloid,	50	------	-----	Prehnite	-----	---	-----	-------	------	---	----	----	Orthoclase	Epidote
Huron Mine,	51	------	Epidote	------	Quartz	---	-----	-------	------	---	----	----	------	----
Shelden & Columbian,	52	------	-----	------	Quartz	Calcite. Quartz.	-----	-------	------	---	----	----	------	----
Huron Mine,	53	------	-----	------	Quartz	---	Copper	-------	------	---	----	----	------	----
Ragged Amygdaloid,	54	------	-----	------	-----	---	-----	-------	------	---	----	----	Orthoclase	Calcite Chlorite Clay
" "	55	------	-----	------	-----	---	-----	-------	Analcite	---	----	----	------	----
"Ancient Pit" Bed, Douglass,	56	------	Epidote	------	Quartz	---	-----	-------	------	---	----	----	Orthoclase	----
-uret V'n,' Huron,	57	------	Ankerite ?	------	Quartz	---	Bornite. Chalcocite	-------	------	---	----	----	------	----

often impossible to distinguish as to the relative ages of the two. But specimens in my collection offer conclusive proof that each of the following cases occur.

I.—*The copper was present before the calcite began to form, and became enclosed in the growing crystal.*

In this case the copper and its associated minerals generally form the basis on which the calcite rests, and the crystals of the latter exhibit entering faces wherever the surface of the crystal is in contact with the copper; it should seem to indicate an effort at those points to crystallize free from the foreign substance, by forming separate individuals. But on the finished crystal the traces of this tendency is visible, generally, only in the comparatively very small entering faces at the contact with the copper.

In this way calcite crystals, formed in a cavernous mass of copper, are intersected internally by a perfect net-work of thin plates of the metal, and yet preserve their cleavage unaffected; but wherever the copper comes in contact with the surface of the crystal, the small entering faces are present.

II.—*The crystal of calcite was partly formed, then became incrusted with copper, and was finished by a new growth of calcite over the metallic film.*

A most remarkable instance of this case is that of a crystal about 2 inches long—a steep scalenohedron—with a basal termination of about 1 square inch surface. At this stage of its growth it was covered, over nearly the whole surface, with a thin coating of copper. The basal termination on scalenohedrons of calcite is as rare on Lake Superior as elsewhere, and in the few instances where I have seen it, it lacks the polish which indicates perfect growth. The tendency to complete the point of the scalenohedron is well shown on this specimen; over the partially copper-coated basal plane there are scattered a large number of perfectly pointed scalenohedrons—two or three of these are $\frac{1}{8}$ to $\frac{1}{2}$ inch. high—and others are scattered over the side-faces. All of these younger crystals are arranged in perfect uniformity with the plan of the underlying, older individual.

Those portions of the surface on which the copper-coating is perfect have no younger calcite crystals; these occur where the metallic film is thinnest and more or less perforated.

The copper is not confined absolutely to the surface of the crystal on which it lies: it penetrates to a slight distance along the cleavage-planes, and the result is an exceedingly delicate treiculation on its under surface. The calcites which are planted on the copper contain brilliant particles of the metals

swimming, if one may use the word, in the interior of the crystals; and these are so disposed as to lead to the idea that throughout the growth of the younger crystals they had to contend with the continued deposition of the metal. Thus one of the new scalenohedrons, after growing to the height of $\frac{1}{4}$ inch, was, like the underlying one, also ended with a basal termination, on which again smaller new and well pointed individuals were built up.

II.—*The copper has entered the calcite crystal since its growth was finished.*

A specimen, in my collection, illustrates this remarkably well. It is a cleavage-rhombohedron of opaque calcite, traversed by intersecting sheets of copper, which are wholly independent of the cleavage planes. On detaching the copper from the calcite, the surface of the latter appears rough; it is a fracture oblique to the cleavage, and the face of the fracture is formed by countless corners, or solid angles, of minute cleavage-rhombohedrons, as is fully proved by the reflexion of the light. The copper-sheets, which are about $\frac{1}{40}$ inch thick, reproduce this very completely.

Another very remarkable specimen is from the cement of the Albany and Boston conglomerate. It is about 1 inch in diameter, and consists of opaque white calcite. The continuity of the cleavage shows it to be a single individual, though it passes on the edges without any sharp demarkation into the common cement of the conglomerate. This calcite is traversed by continuous sheets of copper $\frac{1}{300}$ to $\frac{1}{40}$ inch thick, which are perfectly straight. These sheets are parallel to several planes, (nearly all of which are independent of the cleavage) and intersect each other. In each of the sets thus formed the sheets are perfectly parallel, and are separated by plates of calcite, which are in places as thin as the copper itself. Where three such sets intersect each other, the resulting solid appears composed of concentrically arranged laminæ of copper and calcite. In some parts of the specimen the copper predominated over the calcite. Wherever the faces of the copper laminæ are exposed, they are marked with a delicate, reticulated tracery, indicating the lines of intersection of the sheet with the cleavage planes of the crystal. The cement in the vicinity of the calcite is impregnated with copper; in places it is almost wholly replaced by the metal in the fine granular condition called "brick copper," and into this the laminæ of metal extend, without break, from the calcite. This specimen is really a pseudomorph of copper after calcite.

Copper and Silver.—It is a well known fact that these two metals occur in the metallic state, in the Lake Superior depos-

its, in the most intimate contact with each other, and yet without being mutually alloyed. Even at the contact they are not absolutely joined together, for after rolling out a piece of copper containing spots of silver, the two metals become more or less separated, and may often be readily detached from each other. I have not been able to obtain any material that would throw light upon the relative ages of the two metals.

[To be continued.]

ART. XXXIV.—*On Photographing Histological Preparations by Sunlight;* by J. J. WOODWARD, Asst. Surgeon U. S. Army. Report to Surgeon General J. K. Barnes, U. S. Army. Washington, June 9, 1871.

IN January, 1870, I had the honor to submit to you a report in which I detailed the results of a series of experiments, which showed the superiority of the electric and magnesium lights over sunlight, as heretofore employed, for the production of photo-micrographs of the soft tissues. In June of the same year I made a report in which I showed that similar results could be obtained with the oxy-calcium light. With these various artificial sources of light, I obtained pictures which appeared to me to be "clearer and better defined than any photographs of similar objects I had hitherto seen produced by sunlight."

So many cloudless days are offered to the photographer in Washington, that I could not but regret these results; yet they appeared to be final at the time of writing. During the last few months, however, I have found improved methods of using the light of the sun for photographing the soft tissues, and have arrived at results which must materially modify the conclusions of my former reports.

Not that I have anything to withdraw from the opinions I have expressed, as to the certainty and success attending the use of artificial lights for the purpose named, but I have much to add with regard to the most advantageous methods of using the light of the sun for obtaining satisfactory pictures of tissue preparations, and such other objects as approximate them in optical characteristics.

If a well made preparation of some normal tissue, or of some pathological growth, stained with carmine, silver, or gold, and mounted temporarily in glycerine, or permanently in Canada balsam, be illuminated by white cloud illumination, or by lamp light, and found to be all that could be desired, it will nevertheless appear very unsatisfactory if illuminated by the direct rays of the sun.

re glancing through the tube of the instrument, dazzled owerful light, discerns amidst the blaze, innumerable rings, produced by diffraction and interference which the normal appearances of the preparation and render retation impossible.

image be received upon a white screen similar phenotrude themselves, destroying the clearness of the picture, no longer injuriously affecting the eye; and if monoc light is employed, although the disorderly play of appears, black rings and lines of the most manifold and direction take their place. Pictures produced ese circumstances are of course quite useless, and the occurs not merely in the case of tissue preparations, very large number of other objects.

ape these disagreeable results, it has heretofore been the to pass the solar pencil through a piece of ground glass. n is recommended in all the treatises on photo-microand has hitherto been employed in the solar work done Army Medical Museum. The method is effectual in id of the diffraction and interference phenomena comf; an image is obtained which is clear and satisfactory e looking down the tube, but it appears very weak on n, and is sadly deficient in contrast. These faults are ed in photographs of objects thus illuminated, and, r, the time of exposure is enormously increased. Such are decidedly inferior to those which can be obtained agnesium, or even by the calcium light, with which d glass is used.

re now to call your attention to the fact that in the some recent experiments, I have ascertained that the n and interference phenomena above complained of, prevented by the use of a suitable condensing lens, ter than by the ground glass; that by this plan the may be greatly diminished, say from three minutes hundred diameters, to a fraction of a second, and that ting pictures are not merely quite as free from diffracinterference phenomena as the best that can be obtained ground glass is used, but are characterized by greater and superior sharpness of definition.

etails of my new method are as follow: The microscope aced on a shelf at the window of the dark room, and its de horizontal, the achromatic condenser is illuminated ar pencil reflected from a heliostat upon a moveable itside the shutter and thence into the dark room, predescribed in my original paper on photo-micrography.*

* This Journ., II, vol. xlii, p. 189, Sept., 1866.

No ground glass is used, but instead a lens mounted in a suitable tube is fixed in the opening of the shutter through which the solar pencil enters. This lens is an achromatic combination about two inches in transverse diameter and of about ten inches focal length. It is placed at such a distance from the achromatic condenser that the solar rays are brought to a focus and begin again to diverge before they reach the lowest glass of the achromatic condenser.

For anatomical preparations requiring for their display from two to five hundred diameters, I use an ⅛th of an inch objective, without an eyepiece, obtaining the precise power desired by variations in the distance of the sensitive plate from the stage of the instrument. I have lately given the preference to immersion objectives, the corrections of which I find are generally well suited to photographic requirements.

Now with an 1-8th objective and the arrangement above described, the field is so brilliantly illuminated that the eye cannot safely be permitted to look down the tube. The image is therefore received on a piece of white card-board, and sitting by the microscope to make the adjustment, I view the card with both eyes precisely as in the case of the ordinary solar microscope. With these arrangements, the card-board placed from two to four feet from the stage of the microscope is sufficiently well illuminated to permit distinct vision, even when objectives of the shortest focus are used and powers of five to ten thousand diameters obtained. While the object is thus seen on the white screen in its natural colors, the cover corrections, focussing, management of the achromatic condenser, and selection of the portion of the preparation to be photographed, are readily managed. When all is satisfactory, I insert an ammonio-sulphate cell between the large lens and the achromatic condenser, and draw down the velvet hood which prevents leakage of light from about the microscope into the dark room; then going to the plate holder, I make the final focussing in the usual way on the ground glass, or on plate glass with the help of a focussing glass, according to the nature of the object.

With powers of five hundred diameters or less, I at first experienced some difficulty in giving the right exposure; for as the time required was but a fraction of a second, it was a matter of some difficulty to regulate it with precision. At length I succeeded by arranging a sliding shutter, with a transverse slit of variable width, so adjusted as to fall with its own weight before the tube of the microscope, the exposure being made during the passage, and the time of exposure regulated by the width given to the slit.

Of course it occurred to me that for such short exposures the heliostat might be dispensed with, and I found on trial without

that a large right-angled prism used in the position of total flection, or even an ordinary mirror gave excellent results; e exposures being even shorter than when the heliostat was ed, since there was but a single reflection. I could not satisfy yself, however, that the quality of the pictures differed from ose obtained with the help of the heliostat, except perhaps at in certain cases the prism seemed to offer advantages which ill be referred to hereafter. Under these circumstances the liostat appears desirable for ordinary use, since the solar encil being thrown in a constant direction, the trouble of ad-sting the illumination of a series of objects is considerably minished; but I have convinced myself by trial that equally od pictures can be produced without it, even with very high owers, a circumstance of considerable interest where motives economy preclude the microscopist from procuring this con-enient instrument

A few remarks with regard to certain points in the procedure bove sketched seem called for.

First, with regard to the selection of objectives suitable for hotographic work of this kind. The power of the objective to e used will depend of course upon the details it is desired to isplay. I find it best to use the naked objective without eye-iece or amplifier, and not as a rule to fix the sensitive plate ore than three or four feet from the stage of the microscope. n 1-8th objective may be conveniently employed to obtain owers of from two to five or six hundred diameters, a 1-16th r higher powers up to twelve or fifteen hundred diameters. uitable amplifiers or even eye-pieces may be used in either se, with great increase of the magnifying power, and often ith admirable scenic effect, but there is always a certain loss f definition. Still such amplifications may sometimes be ad-antageously resorted to, especially in the case of objects which resent very minute details; for in these cases the paper prints ill often lose many of the fine details of the negative, and the ss of definition incurred by the amplifier or eye-piece is not nfrequently less than that encountered in attempting to transfer paper a negative prepared with insufficient magnifying power. hus far my experience is decidedly in favor of using sufficient ower in the first instance, rather than attempting to enlarge egatives taken with less power.

The objective selected should of course be unexceptional in efining power, and should always be specially corrected for hotography. It has been erroneously stated by Moitessier,* at if an ammonio-sulphate or other blue cell be interposed in e solar pencil, all special corrections of the objective may be

* La Photographie Appliquée aux Recherches Micrographiques, par A. Moites-er, Paris, 1866, p. 180 et seq.

dispensed with. This proposition, which has been adopted by many other writers, appears plausible, but a little consideration will show it to be quite erroneous.

Every one knows that a good objective must be free from spherical, as well as from chromatic, aberration. Of course the use of monochromatic light disposes of the chromatic trouble. Not so with the spherical aberration. Now this aberration, like the chromatic, is corrected mainly by the just combination of flint with crown glass in the several pairs which constitute the objective. If these are so adjusted as to correct spherical aberration as nearly as possible for white light, they will no longer do so for light which has passed through the ammonio-sulphate of copper. Until objective makers take this fairly into consideration, the microscopist who desires to photograph what he sees is left to a happy chance in the selection of his objectives. For even those makers who profess to prepare objectives "specially corrected for photography" do not deal any too well with the problem. If they would test their objectives, while making them, with violet light, we should have better results; for with such illumination the eye can see all that photography can execute, and no more.

But this circumstance fortunately enables the microscopist to select from the objectives in the market those which are suitable for photography. It is only necessary to test their performance when illuminated by sunlight, which has passed through an ammonio-sulphate cell. Now it fortunately happens that the high power immersion objectives of certain makers, especially those of Powell & Lealand, possess very nearly the corrections which theory would indicate as best adapted for photographic use. Nevertheless it can hardly be doubted that even these objectives could be greatly improved if the makers would take into consideration the principles involved in the foregoing remarks.

A second point, which deserves attention, is the use of the large condensing lens above described. This lens, it will be understood, corresponds with the large condensing lens of the ordinary solar microscope, while the achromatic condenser takes the place of the so-called field glass of the same instrument. It has already been mentioned that this lens should be placed at such a distance from the achromatic condenser that the solar rays may be brought to a focus, and begin again to diverge before they reach its lowest glass. A different arrangement is usually employed in the solar microscope, the field glass being placed at such a distance from the first condenser that the solar rays impinge upon it before they come to a focus. As a consequence, the convergent pencils proceeding from the first lens are still further converged by the field glass, and a burning

:us of heat, as well as of light, is produced, which is damag-
ʒ to the preparation as well as to the balsam cement of the
jectives used. If, however, the rays from the first lens are
rmitted to come to a focus and to begin to diverge before
iking the second, this latter can readily be adjusted so as to
ing the illuminating rays to a handsome focus, while the heat
ys, after passing the second lens, become parallel or even
vergent according to the position of the achromatic condenser,
d all trouble from the solar heat is thus completely avoided.
successfully may this separation be effected, indeed, that I
ve frequently obtained light enough to give distinct vision
d admirable definition on the card-board screen with five
ousand linear diameters or even higher powers (obtained by
e immersion 1-16th, an amplifier, and four feet or greater dis-
nce), while the heat was so slight that the drop of water used
th the immersion lens did not require renewal oftener than
out once in two hours.

I had employed this device for several months, and supposed
to be quite novel, when I read the paper of the late distin-
ished President of the Royal Microscopical Society of London,
e Rev. J. B. Reade, "On the separation of the rays of heat
m the rays of light in solar and oxy-hydrogen-gas micro-
opes."* I learned from that article that Mr. Reade had de-
sed this very plan as an improvement to the solar microscope
long ago as 1836. The advantages attained may be stated
his own lucid words.

"It is evident by this arrangement of lenses we convert the
rallel solar beam first of all into a cone of light-giving rays
thin a cone of heat-giving rays, and the principal focus of
at is farther from the condensing lens than the principal
cus of light. But after these rays cross the axis we have,
nversely, an equal and opposite cone of heat-giving rays
thin a cone of light-giving rays, and a plano-convex lens or
misphere, if placed in this second cone at the distance of its
n focal length from the principal focus of heat, will be at a
stance greater than its focal length from the principal focus of
ht; and, consequently, the rays of heat, after passing through
is lens, will become parallel, while the rays of light converge
a second focus. I have approximately measured the heating
wer of the thermal rays of the second cone when rendered
rallel by the plano-convex lens, and I found, in the month of
cember, that the mercury in a sensitive thermometer, when
aced in the second focus, did not reach 90° Fah., while at the
me time the heat at the focus of the first cone was sufficient
discharge gunpowder."

* The British Journal of Photography, Dec. 16, 1870, p. 590.

Mr. Reade appears to have experimented with low power objectives only, for he speaks merely of such preparations as the head of a flea. He therefore succeeded very well by using a single lens in his field glass. With such powers as the immersion $\frac{1}{8}$th and $\frac{1}{16}$th, I find it better to use an ordinary achromatic condenser instead. The principles involved are of course identical. For the first condenser also, I have been using an achromatic combination of the dimensions and focal length above mentioned, taken from the back of an ordinary photographic protrait tube; but I am not sure that a simple planoconvex lens of the requisite diameter and focal length would not answer every purpose.

The introduction of the ammonio-sulphate cell would of itself prevent the passage of most of the heat rays falling upon it, but if this were the only means of excluding them, it would not be possible to focus primarily with white light on the cardboard screen in the manner which I have found so convenient.

I have already stated that the time of exposure required for the production of pictures magnified five hundred diameters or less, was a fraction of a second. With higher powers it increases, varying with the management of the achromatic condenser. For four thousand diameters I have sometimes needed as much as twenty-five seconds.

So long as the exposure is greater than a second, the requisite time may readily be given with a piece of velvet, or a cardboard screen held in the hand. For shorter exposures some mechanical contrivance is indispensable. That alluded to above seems to answer every purpose, and is arranged as follows: A wooden screen is fixed between the microscope and the sensitive plate, as close as convenient to the microscope. To prevent side lights reaching the plate, the screen is connected with the window shutter by velvet curtains, which can be turned aside to manipulate the instrument, and be let down at the proper time. A circular hole, three inches in diameter, is made in the screen opposite the tube of the microscope for the transmission of the image. In front of this a light shutter slides loosely up and down, held in place by a cleat of wood on each side, the design being to permit the shutter to fall edge foremost with as little friction as possible. The shutter may be made of thin metal, of wood, or even of card-board. I am using one of pine wood the $\frac{1}{16}$th of an inch thick—I have used one of cardboard with equal success. In the shutter is an opening, three inches wide by ten long, covered with a card-board slide, by means of which any width of slit, from a fraction of an inch to ten inches, can be given. The part of the shutter below the slit closes the aperture through which the image passes when the shutter is fixed in place before the exposure is made. On

rawing a wooden trigger the shutter is started on its fall, which ı arrested by a piece of string of suitable length. The exposure as now been made, but the aperture through which the image asses is again closed, this time by the part of the shutter above ıe slit. The shutter is so light that the jar caused by the ıdden arrest of its motion by the string is too trifling to do ny damage to the microscopic apparatus, and as it occurs after ıe exposure is over it cannot affect the image. I find that if, 'hen the shutter is started, the lower edge of the slit is an inch bove the aperture through which the image passes, a con-enient velocity is attained for a magnifying power of two to ve hundred diameters, arranged as I have described. For still horter exposures, necessitated by lower powers or other circum-tances, it would be best to start the shutter from a greater eight, which would give greater velocity to the passage of the lit, and any available fraction of time desired might thus con-eniently be obtained. The whole arrangement is inexpensive, nd may be manufactured in a few hours by any one, out of a eal board, a few pieces of card-board and a yard or two of otton velvet.

Of course the fractional measures of time obtained in this 'ay are not absolute, since the friction must be variable, unless ıe apparatus were made in a more costly manner of metal. ƅut I have found that the variations thus introduced are so mall that they may be disregarded, and that while the start-ıg point remains the same, the width of the slit in the falling hutter indicates fractions of time which may confidently be ounted upon to give proportional photographic results.

The next subject for remark is the arrangement employed 'hen the heliostat is dispensed with.

For this purpose the contrivance usually employed for the olar microscope answers very well. A circular disc of brass, 'ith toothed edges, is let into a square plate of the same metal, nd is turned by a small toothed wheel, to which a suitable utton or milled head is attached. Through the center of the isc passes a tube six or eight inches long and two inches in iameter, the outer extremity of which is fitted to receive the ırge condensing lens. Just below this tube an arm is firmly ttached to the outer surface of the disc for the purpose of arrying the mirror or right-angled prism, to which any desired ıclination can be given by a rod passing through the disc by ıe side of the tube. The whole arrangement is quite like the imilar parts of the ordinary solar microscope, and hence needs o minute description: it is fitted into a window shutter, which ıust of course face to the south, and the room being darkened, ıe motions of the mirror or prism can readily be controlled

from within. If the condensing lens is used, I do not think any material advantage can be obtained from the prism, and its expense is a decided objection. In the winter season, in this latitude, a prism of over five inches hypothenuse is required, and its cost is a serious item. An ordinary glass mirror answers, I think, quite as well for the tissues and most other purposes. There are, however, certain objects, such as the Pleurosigmata and some other diatoms, the Nobert's test-plate, and the scales of certain insects, for which the condensing lens is unnecessary. The achromatic condenser, illuminated by a parallel solar pencil, answers better in these cases, and if it is properly managed no diffraction or interference phenomena are produced. I am satisfied that in such cases the pure parallel pencil obtained from the prism gives better definition to the image than can be obtained by the double pencil reflected from an ordinary glass mirror. A mirror silvered on the reflecting surface would, I suppose, answer the same purpose; but such mirrors are not permanent, and are troublesome to keep in order while they last. Moreover, if the prism is used only for this purpose, a very small and cheap one will answer, since a pencil half an inch in diameter is all that is required. Such a small right-angled prism is furnished with most large microscopes, and can readily be mounted outside the brass disc so as to answer the special purpose indicated. For all those objects which require the large condensing lens to avoid diffraction and interference, a common glass mirror will answer well enough. For lower powers than two hundred diameters, however, the ordinary mirror will often be found to reflect too much light, and the image on the card-board screen will be found too brilliant to be conveniently observed for any length of time. In such cases a piece of plain unsilvered plate glass may be substituted for the mirror. The greater portion of the solar light passes through it and is lost, but enough is reflected to make pictures of four hundred diameters in from two to three seconds exposure, and these pictures have all the qualities of those made with ordinary mirrors. I have tried instead to diminish the light by absorbing a part, using for this purpose an ammonio-sulphate cell of considerable thickness, but find that this plan diminishes the contrast and definition of the image, which is not the case when a mirror of simple plate glass is used as above described.

With regard to the management of the plate-holder, the apparatus for focussing, and other accessory arrangements, I need only say that I employ for the solar light the same simple plan which I have described in full in my reports on the use of artificial lights in photo-micrography.

Since making the experiments which have led to the foregoing results, I have modified my method of dealing with the

electric light in photographing the tissues. I first render the divergent pencil proceeding from the carbon points as nearly parallel as possible by means of the condenser, usually supplied with electric lamps for this purpose, and then introduce into the parallel pencil, instead of a ground glass, the very same condensing lens described above for the process with solar light. The image is received primarily on a card-board screen, and the remaining details do not differ from what has been related above. The time of exposure does not exceed a single second for four hundred diameters, and the sharpness of the pictures exceeds any of my former results. Indeed, with this new arrangement, I must say that the electric light appears to me to retain the apparent superiority over sunlight, remarked in my paper on the use of this method of illumination in photo-micrography, at least in the case of all those objects which in themselves possess but little contrast. For well made tissue preparations, however, I find the best work I can do with the electric light so similar to the best attainable by sunlight, used as above described, that I should rarely take the trouble to set up the battery and work the electric lamp, unless it was desirable to work at night or in unfavorable weather.

[The memoir is accompanied by photographic plates of tissues, magnified 400 to 500 diameters, as examples of the results obtained in the manner described, and concludes with description of the preparations.]

ART. XXXV.—*Barometrical Measurements in Ecuador;* by W. REISS and A. STÜBEL. Translated from the Spanish by Professor ORTON, Vassar College.

[THE following is an abstract of the principal altitudes near Quito, as determined by the able North German Expedition in 1870–1. Schmidt's value of the *vara*, given below, differs from the standard in the U. S. Office of Weights and Measures by –·0015 meter. I have reduced the meters to English feet. It is remarkable that every successive measurement of the Quitonian Andes gives a reduced elevation. Thus: altitude of Quito by Humboldt, 9570; Orton, 9520; Reiss and Stübel, 9350;—of Panecillo by Humboldt, 10,244; Orton, 10,101; R. and S., 10,006;—of Pichincha by Humboldt, 15,922; Orton, 15,827; R. and S., 15,704;—of the crater by Wisse and Moreno, 13,600; Orton, 13,300; R. and S., 13,175.]

NOTE.—The altitudes are calculated in meters above the level of the sea, one meter equaling 1·1963 Spanish vara. The greater part of the observations were made with the barometer; but trig

onometrical measurements were taken of some notable points. The letters B and T indicate these different means, and the numbers show the times of observations. As this work is provisional, the authors reserve the privilege of making corrections in the future, which, however, will be insignificant.

Place.	Altitude, Meters.	Feet.	Method.
Tulcan, plaza (northern frontier),	2,977	9,767	1 B.
Chota bridge,	1,532	5,026	1 "
Isambal, foot of Yanaurcu,	4,041	13,257	3 "
Top of Yanaurcu,	4,556	14,947	2 "
El Fuyafuya, north summit,	4,294	14,087	2 "
" south "	4,279	14,038	T.
Caricocha,	3,711	12,174	"
Tabacundo,	2,889	9,478	1 B.
Salinas, plaza,	1,639	5,377	3 "
Hatuntaqui, plaza,	2,407	7,897	2 "
Cotacachi, plaza,	2,453	8,048	24 "
Otovalo, plaza,	2,581	8,468	1 "
Hacienda of Cuicocha,	2,747	9,012	2 "
Border of the Lake Cuicocha,	3,118	10,229	T.
Top of Cotacachi, S.E. point,	4,960	16,272	"
" " N.W. "	4,966	16,291	"
" " N. "	4,829	15,842	"
Snow-limit on Cotacachi, S.W. side,	4,620	15,157	"
" " " E. "	4,694	15,399	"
San Pablo, plaza,	2,726	8,943	3 B.
" " lake,	2,697	8,848	2 "
Top of Cusin,	4,012	13,162	2 "
La Esperanza, plaza,	2,344	7,690	16 "
Top of Curilche,	3,882	12,735	2 "
Lake within the crater,	3,801	12,470	2 "
Top of Cerro Cunru,	3,338	10,950	2 "
Lake in the crater,	3,317	10,882	1 "
Yaguarcocha,	2,253	7,391	4 "
Ibarra, plaza,	2,225	7,300	4 "
Imanta, "	2,422	7,946	2 "
Peguche, hacienda,	2,556	8,385	3 "
Guaillabamba, pueblo,	2,106	6,909	3 "
Alchipichi bridge,	1,719	5,639	2 "
Pomasqui, plaza,	2,507	8,225	2 "
Cotocollao, "	2,802	9,193	4 "
Perucho, "	1,830	6,004	3 "
Colicalí, pueblo,	2,792	9,160	2 "
Frutillas,	3,133	10,278	2 "
Mindo, hacienda of San Vicente,	1,264	4,147	16 "
El Pondoña, N.E. summit,	2,940	9,645	1 "
Pailon,	2,985	9,793	1 "
Junction of Rio Blanco with Rio del Volcan,	2,078	6,817	7 "
Hacienda of San José in Lloa,	3,091	10,140	26 "
Top of Rucu-Pichincha,	4,737	15,540	T.

Place.	Altitude, Meters.	Feet.	Method.
ırguachana,	4,090	13,254	1 B.
f Guagua-Pichincha,	4,787	15,704	T.
m of the crater,	4,016	13,175	1 B.
f the mound in the crater,	4,087	13,408	1 "
f Panecillo,	3,050	10,006	2 "
ingara, hacienda de las Monjas,	2,648	8,687	1 "
e of Guápulo,	2,545	8,349	1 "
h "	2,690	8,825	2 "
aco, plaza,	2,390	7,841	3 "
bo, "	2,484	8,149	2 "
nda of Guachalá,	2,801	9,189	4 "
nbe, pueblo,	2,852	9,357	2 "
f Atacazo, edge of crater,	4,539	14,891	2 "
.l within crater,	4,242	13,916	2 "
illo, tambo,	2,802	9,193	7 "
, pueblo,	2,922	9,586	2 "
f Corazon,	4,787	15,704	2 "
ıchi, tambo,	2,935	9,629	1 "
ːantana peak on Rumiñagui,	3,839	12,594	2 "
m of the Caldera,	3,755	12,319	1 "
between Capacocha and Sachacocha,	4,192	13,752	1 "
nda of Pedregal,	3,531	11,584	1 "
f Pasochoa,	4,255	13,959	2 "
Ilaló,	3,161	10,370	2 "
ası́, plaza,	2,587	8,487	1 "
nda of Sñr. Jijon, Chillo,	2,518	8,261	1 "

XXXVI.—*Inaugural Address before the British Association Edinburgh, August 2d ;* by Sir WILLIAM THOMPSON, sident of the Association.

Kew Observatory.

* * One of the most valuable services to science the British Association has performed has been the es- ɔment, and the twenty-nine years maintenance, of its ob- ory. The Royal Meteorological Observatory of Kew ›uilt originally for a sovereign of England who was a ıs amateur of astronomy. George the Third used contin- to repair to it when any celestial phenomenon of peculiar st was to be seen: and a manuscript book still exists with observations written into it by his own hand. After ıilding had been many years unused, it was granted, in ar 1842, by the Commissioners of her Majesty's Woods orests, on application of Sir Edward Sabine, for the pur- f continuing observations (from which he had already de- important results) regarding the vibration of a pendulum

in various gases, and for the purpose of promoting pendulum observations in all parts of the world. The Government granted only the building—no funds for carrying on the work to be done in it. The Royal Society was unable to undertake the maintenance of such an observatory; but, happily for science, the zeal of individual fellows of the Royal Society and members of the British Association gave the initial impulse, supplied the necessary initial funds, and recommended their new institution successfully to the fostering care of the British Association. The work of the Kew Observatory has, from the commencement, been conducted under the direction of a committee of the British Association: and annual grants from the funds of the Association have been made toward defraying its expenses up to the present time. To the initial object of pendulum research was added continuous observations of the phenomena of meteorology and terrestrial magnetism, and the construction and verification of thermometers, barometers, and magnetometers designed for accurate measurement. The magnificent services which it has rendered to science are so well known that any statement of them which I could attempt on the present occasion would be superfluous. Their value is due in a great measure to the indefatigable zeal and the great ability of two Scotchmen, both from Edinburgh, who successfully held the office of Superintendent of the Obsertory of the British Association—Mr. Welsh for nine years, until his death in 1859, and Dr. Balfour Stewart from then until the present time. Fruits of their labors are to be found all through our volumes of Reports for these twenty-one years.

The institution now enters on a new stage of its existence. The noble liberality of a private benefactor, one who has labored for its welfare with self-sacrificing devotion unintermittingly from within a few years of its creation, has given it a permanent independence, under the general management of a committee of the Royal Society. Mr. Gassiot's gift of 10,000*l.* secures the continuance at Kew of the regular operation of the self-recording instruments for observing the phenomena of terrestrial magnetism and meteorology, without the necessity for further support from the British Association.

Physical Observatories and Laboratories.

The success of the Kew Magnetic and Meteorological Observatory affords an example of the great gain to be earned for science by the foundation of physical observatories and laboratories for experimental research, to be conducted by qualified persons, whose duties should be, not teaching, but experimenting. Whether we look to the honor of England, as a nation which ought always to be the foremost in promoting physical science, or to those vast economical advantages which must accrue from *such establishments*, we cannot but feel that experimental re-

search ought to be made with us an object of national concern, and not left, as hitherto. exclusively to the private enterprise of self-sacrificing amateurs, and the necessarily inconsecutive action of our present governmental departments and of casual committees. The Council of the Royal Society of Edinburgh has moved for this object in a memorial presented by them to the Royal Commision on Scientific Education and the Advancement of Science. The Continent of Europe is referred to for an example, to be followed with advantage in this country, in the following words:—

"On the continent there exist certain institutions, fitted with instruments, apparatus, chemicals, and other appliances, which are meant to be, and which are made, available to men of science, to enable them, at a moderate cost, to pursue original researches."

This statement is fully corroborated by information, on good authority, which I have received from Germany, to the effect that in Prussia "every university, every polytechnical academy, every industrial school (*Realschule* and *Gewerbeschule*), most of the grammer-schools, in a word, nearly all the schools superior in rank to the elementary schools of the common people, are supplied with chemical laboratories and a collection of philosophical instruments and apparatus, access to which is most liberally granted by the directors of those schools, or the teachers of the respective disciplines, to any person qualified, for *scientific experiments.* In consequence, though there exist no particular institutions like those mentioned in the memorial, there will scarcely be found a town exceeding 5,000 inhabitants but offers the possibility of *scientific explorations* at no other cost than reimbursement of the expense for the materials wasted in the experiments."

Further, with reference to a remark in the memorial to the effect that in respect to the promotion of science, the British Government confines its action almost exclusively to scientific instruction, and fatally neglects the advancement of science, my informant tells me that, in Germany, "professors, preceptors, and teachers of secondary schools are engaged on account of their skilfulness in *teaching*; but professors of universities are never engaged unless they have already proved, *by their own investigations*, that they are to be relied upon for the *advancement of science.* Therefore every shilling spent for instruction in universities is at the same time profitable to the advancement of science."

The physical laboratories which have grown up in the Universities of Glasgow and Edinburgh, and in Owen's College, Manchester, show the want felt of colleges of research; but they go but infinitesimally toward supplying it, being absolutely destitute of means, material or personal, for advancing science

except at the expense of volunteers, or securing that volunteers shall be found to continue even such little work as at present is carried on.

The whole of Andrew's splendid work in Queen's College, Belfast, has been done under great difficulties and disadvantages, and at great personal sacrifices; and up to the present time there is not a student's physical laboratory in any one of the Queen's Colleges in Ireland—a want which surely ought not to remain unsupplied. Each of these institutions (the four Scotch universities, the three Queen's Colleges, and Owen's College, Manchester) requires two professors of Natural Philosophy—one who shall be responsible for the teaching, the other for the advancement of science by experiment. The University of Oxford has already established a physical laboratory. The munificence of its Chancellor is about to supply the University of Cambridge with a splendid laboratory, to be constructed under the eye of Prof. Clerk Maxwell. On this subject I shall say no more at present, but simply read a sentence which was spoken by Lord Milton in the first Presidential Address to the British Association, when it met at York in the year 1831:—"In addition to other more direct benefits, these meetings [of the British Association], I hope, will be the means of impressing on the Government the conviction, that the love of scientific pursuits, and the means of pursuing them, are not confined to the metropolis; and I hope that when the Government is fully impressed with the knowledge of the great desire entertained to promote science in every part of the empire, they will see the necessity of affording it due encouragement, and of giving every proper stimulus to its advancement."

Besides abstracts of papers read, and discussions held, before the Sections, the annual Reports of the British Association contain a large mass of valuable matter of another class. It was an early practice of the Association, a practice that might well be further developed, to call occasionally for a special report on some particular branch of science from a man eminently qualified for the task. The reports received in compliance with these invitations have all done good service in their time, and they remain permanently useful as landmarks in the history of science. Some of them have led to vast practical results; others of a more abstract character are valuable to this day as powerful and instructive condensations and expositions of the branches of science to which they relate. I cannot better illustrate the two kinds of efficiency realized in this department of the Association's work than by referring to Cayley's 'Report on Abstract Dynamics,' and Sabine's 'Report on Terrestrial Magnetism,' (1838).

To the great value of the former, personal experience of benefit received enables me, and gratitude impels me, to testify. In a few pages full of precious matter, the generalized dynamical equations of Lagrange, the great principle evolved from Maupertius' "least action" by Hamilton, and the later developments and applications of the Hamiltonian principle by other authors, are described by Cayley so suggestively that the reading of thousands of quarto pages of papers scattered through the *transactions* of the various learned societies of Europe is rendered superfluous for any one who desires only the essence of these investigations, with no more of detail than is necessary for a thorough and practical understanding of the subject.

Terrestrial Magnetism.

Sabine's Report of 1838 concludes with the following sentence:—"Viewed in itself and its various relations, the magnetism of the earth cannot be counted less than one of the most important branches of the physical history of the planet we inhabit; and we may feel quite assured that the completion of our knowledge of its distribution on the surface of the earth would be regarded by our contemporaries and by posterity as a fitting enterprise of a maritime people, and a worthy achievement of a nation which has ever sought to rank foremost in every arduous and honorable undertaking." An immediate result of this report was that the enterprise which it proposed was recommended to the Government by a joint Committee of the British Association and the Royal Society with such success, that Capt. James Ross was sent in command of the Erebus and Terror to make a magnetic survey of the Antarctic regions, and to plant on his way three magnetical and meteorological observatories, at St. Helena, the Cape, and Van Diemen's Land. A vast mass of precious observations, made chiefly on board ship, were brought home from this expedition. To deduce the desired results from them, it was necessary to eliminate the disturbance produced by the ship's magnetism; and Sabine asked his friend Archibald Smith to work out from Poisson's mathematical theory, then the only available guide, the formulæ required for the purpose. This voluntary task Smith executed skillfully and successfully. It was the beginning of a series of labors carried on with most remarkable practical tact, with thorough analytical skill, and with a rare extreme of disinterestedness, in the intervals of an arduous profession, for the purpose of perfecting and simplifying the correction of the mariner's compass—a problem which had become one of vital importance for navigation, on account of the introduction of iron ships. Edition after edition of the 'Admiralty Compass Manual' has been produced by the able Superintendent of the Compass Department, Capt. Evans, containing chapters of mathematical investi-

gation and formulæ by Smith, on which depend wholly the practical analysis of compass observations and rules for the safe use of the compass in navigation. I firmly believe that it is to the thoroughly scientific method thus adopted by the Admiralty that no iron ship of her Majesty's Navy has ever been lost through errors of the compass. The 'British Admiralty Compass Manual' is adopted as a guide by all the navies of the world. It has been translated into Russian, German, and Portuguese; and it is at present being translated into French. The British Association may be gratified to know that the possibility of navigating ironclad war-ships with safety depends on the application of scientific principles given to the world by three mathematicians, Poisson, Airy, and Archibald Smith.

Returning to the science of terrestrial magnetism, we find in the reports of early years of the British Association ample evidence of its diligent cultivation. Many of the chief scientific men of the day from England, Scotland, and Ireland found a strong attraction to the Association in the facilities which it afforded to them for coöperating in their work on this subject. Lloyd, Phillips, Fox, Ross, and Sabine made magnetic observations all over Great Britain; and their results, collected by Sabine, gave for the first time an accurate and complete survey of terrestrial magnetism over the area of this island. I am informed, by Prof. Phillips, that, in the beginning of the Association, Herschel, though a "sincere well-wisher," felt doubt as to the general utility and probable success of the plan and purpose proposed; but his zeal for terrestrial magnetism brought him from being merely a sincere well-wisher to join actively and cordially in the work of the Association. "In 1838 he began to give effectual aid in the great question of magnetical observatories, and was indeed foremost among the supporters of that which is really Sabine's great work. At intervals, until about 1858, Herschel continued to give effectual aid." Sabine has carried on his great work without intermission to the present day; thirty years ago he gave to Gauss a large part of the data required for working out the spherical harmonic analysis of terrestrial magnetism over the whole earth. A recalculation of the harmonic analysis for the altered state of terrestrial magnetism of the present time has been undertaken by Adams. He writes to me that he has "already begun some of the introductory work, so as to be ready, when Sir Edward Sabine's tables of the values of the magnetic elements deduced from observation are completed, at once to make use of them," and that he intends to take into account terms of at least one order beyond those included by Gauss. The form in which the requisite data are to be presented to him is a magnetic chart of the whole surface of the globe. Materials from scientific trav-

elers of all nations, from our home magnetic observatories, from the magnetic observatories of St. Helena, the Cape, Van Diemen's Land, and Toronto, and from the scientific observatories of other countries, have been brought together by Sabine. Silently, day after day, night after night, for a quarter of a century, he has toiled with one constant assistant always by his side, to reduce these observations and prepare for the great work. At this moment, while we are here assembled, I believe that, in their quiet summer retirement in Wales, Sir Edward and Lady Sabine are at work on the magnetic chart of the world. If two years of life and health are granted to them, science will be provided with a key which must powerfully conduce to the ultimate opening up of one of the most refractory enigmas of cosmical physics, the cause of terrestrial magnetism.

To give any sketch, however slight, of scientific investigation performed during the past year, would, even if I were competent for the task, far exceed the limits within which I am confined on the present occasion. A detailed account of work done and knowledge gained in science Britain ought to have every year. The *Journal of the Chemical Society* and the *Zoological Record* do excellent service by giving abstracts of all papers published in their departments. The admirable example afforded by the German *Fortschritte* and *Jahresbericht* is before us; but hitherto, so far as I know, no attempt has been made to follow it in Britain. It is true that several of the annual volumes of the *Jahresbericht* were translated; but a translation, published necessarily at a considerable interval of time after the original, cannot supply the want. An independent British publication is for many obvious reasons desirable. The two publications, in German and English, would, both by their differences and by their agreements, illustrate the progress of science more correctly and usefully than any single work could do, even if appearing simultaneously in the two languages. It seems to me that to promote the establishment of a British year-book of science is an object to which the powerful action of the British Association would be thoroughly appropriate.

In referring to recent advances in several branches of science, I simply choose some of these which have struck me as most notable.

Accurate and minute measurement.

Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labor in the minute sifting of numerical results. The popular idea of Newton's grandest discovery is that the theory of gravitation flashed into his mind, and so the

discovery was made. It was by a long train of mathematical calculation, founded on results accumulated through prodigious toil of practical astronomers, that Newton first demonstrated the forces urging the planets towards the Sun, determined the magnitudes of those forces, and discovered that a force following the same law of variation with distance urges the Moon toward the Earth. *Then* first, we may suppose, came to him the idea of the universality of gravitation; but when he attempted to compare the magnitude of the force on the Moon with the magnitude of the force of gravitation of a heavy body of equal mass at the Earth's surface, he did not find the agreement which the law he was discovering required. Not for years after would he publish his discovery as made. It is recounted that, being present at a meeting of the Royal Society, he heard a paper read, describing geodesic measurement by Picard, which led to a serious correction of the previously accepted estimate of the Earth's radius. This was what Newton required. He went home with the result, and commenced his calculations, but felt so much agitated that he handed over the arithmetical work to a friend: then (and not when, sitting in a garden, he saw an apple fall) did he ascertain that gravitation keeps the Moon in her orbit.

Faraday's discovery of specific inductive capacity, which inaugurated the new philosophy tending to discard action at a distance, was the result of minute and accurate measurement of electric forces.

Joule's discovery of thermo-dynamic law through the regions of electro-chemistry, electro-magnetism, and elasticity of gases was based on a delicacy of thermometry which seemed simply impossible to some of the most distinguished chemists of the day.

Andrew's discovery of the continuity between the gaseous and liquid states was worked out by many years of laborious and minute measurement of phenomena scarcely sensible to the naked eye.

Great service has been done to science by the British Association in promoting accurate measurement in various subjects. The origin of exact science in terrestrial magnetism is traceable to Gauss's invention of methods of finding the magnetic intensity in absolute measure. I have spoken of the great work done by the British Association in carrying out the application of this invention in all parts of the world. Gauss's colleague in the German Magnetic Union, Weber, extended the practice of absolute measurement to electric currents, the resistance of an electric conductor, and the electromotive force of a galvanic element. He showed the relation beween electrostatic and electromagnetic units for absolute measurement, and made the

beautiful discovery that resistance, in absolute electromagnetic measure, and the reciprocal of resistance, or, as we call it, "conducting power," in electrostatic measure, are each of them a velocity. He made an elaborate and difficult series of experiments to measure the velocity which is equal to the conducting power in electrostatic measure, and at the same time to the resistance in electromagnetic measure, in one and the same conductor. Maxwell, in making the first advance along a road of which Faraday was the pioneer, discovered that this velocity is physically related to the velocity of light, and that, on a certain hypothesis regarding the elastic medium concerned, it may be exactly equal to the velocity of light. Weber's measurement verifies approximately this equality, and stands in science *monumentum ære perennius*, celebrated as having suggested this most grand theory, and as having afforded the first quantitative test of the recondite properties of matter on which the relations between electricity and light depend. A re-measurement of Weber's critical velocity on a new plan by Maxwell himself, and the important correction of the velocity of light by Foucault's laboratory experiments, verified by astronomical observation, seems to show a still closer agreement. The most accurate possible determination of Weber's critical velocity is just now a primary object of the Association's Committee on Electric Measurement; and it is at present premature to speculate as to the closeness of the agreement between that velocity and the velocity of light. This leads me to remark how much science, even in its most lofty speculations, gains in return for benefits conferred by its application to promote the social and material welfare of man. Those who perilled and lost their money in the original Atlantic telegraph were impelled and supported by a sense of the grandeur of their enterprise, and of the world-wide benefits which must flow from its success; they were, at the same time, not unmoved by the beauty of the scientific problem directly presented to them; but they little thought that it was to be immediately, through their work, that the scientific world was to be instructed in a long-neglected and discredited fundamental electric discovery of Faraday's, or that again, when the assistance of the British Association was invoked to supply their electricians with methods for absolute measurement (which they found necessary to secure the best economical return for their expenditure, and to obviate and detect those faults in their electric material which had led to disaster), they were laying the foundation for accurate electric measurement in every scientific laboratory in the world, and initiating a train of investigation which now sends up branches into the loftiest regions and subtlest ether of natural philosophy. Long may the British Association continue a bond of union, and a

medium for the interchange of good offices between science and the world!

Kinetic Theory of Gases—Atoms.

The greatest achievement yet made in molecular theory of the properties of matter is the kinetic theory of gases, shadowed forth by Lucretius, definitely stated by Daniel Bernoulli, largely developed by Herapath, made a reality by Joule, and worked out to its present advanced state by Clausius and Maxwell. Joule, from his dynamical equivalent of heat, and his experiments upon the heat produced by the condensation of gas, was able to estimate the average velocity of the ultimate molecules or atoms composing it. His estimate for hydrogen was 6,225 feet per second at temperature 60° Fahr., and 6,055 feet per second at the freezing point. Clausius took fully into account the impacts of molecules on one another, and the kinetic energy of *relative* motions of the matter constituting an individual atom. He investigated the relation between their diameters, the number in a given space, and the mean length of path from impact to impact, and so gave the foundation for estimates of the absolute dimensions of atoms, to which I shall refer later. He explained the slowness of gaseous diffusion by the mutual impacts of the atoms, and laid a secure foundation for a complete theory of the diffusion of fluids, previously a most refractory enigma. The deeply penetrating genius of Maxwell brought in viscosity and thermal conductivity, and thus completed the dynamical explanation of all the known properties of gases, except their electric resistance and brittleness to electric force.

No such comprehensive molecular theory had ever been even imagined before the nineteenth century. Definite and complete in its area as it is, it is but a well-drawn part of a great chart, in which all physical science will be represented with every property of matter shown in dynamical relation to the whole. The prospect we now have of an early completion of this chart is based on the assumption of atoms. But there can be no permanent satisfaction to the mind in explaining heat, light, elasticity, diffusion, electricity and magnetism in gases, liquids, and solids, and describing precisely the relations of these different states of matter to one another by statistics of great numbers of atoms, when the properties of the atom itself are simply assumed. When the theory, of which we have the first installment in Clausius and Maxwell's work, is complete, we are but brought face to face with a superlatively grand question,—what is the inner mechanism of the atom?

In the answer to this question we must find the explanation not only of the atomic elasticity, by which the atom is a chronometric vibrator, according to Stoke's discovery, but of chemical affinity and of the differences of quality of different chemical

ɜnts, at present a mere mystery in science. Helmholtz's isite theory of vortex-motion in an incompressible friction- liquid has been suggested as a finger-post, pointing a which may possibly lead to a full understanding of the ɜrties of atoms, carrying out the grand conception of Lu- ɪs, who "admits no subtle ethers, no variety of elements fiery, or watery, or light, or heavy principles; nor sup- light to be one thing, fire another, electricity a fluid, mag- n a vital principle; but treats all phenomena as mere prop- or accidents of simple matter." This statement I take an admirable paper on the atomic theory of Lucretius, which ɪred in the *North British Review* for March, 1868, contain- most interesting and instructive summary of ancient and ɜrn doctrine regarding atoms. Allow me to read from ɪrticle one other short passage, finely describing the pres- spect of atomic theory:—"The existence of the chemical , already quite a complex little world, seems very probable; he description of the Lucretian atom is wonderfully ap- ɔle to it. We are not wholly without hope that the real ɪt of each such atom may some day be known—not merely ɜlative weight of the several atoms, but the number in a ı volume of any material; that the form and motion of the of each atom and the distances by which they are sepa- may be calculated; that the motions by which they pro- heat, electricity, and light may be illustrated by exact etrical diagrams; and that the fundamental properties of ɪtermediate and possibly constituent medium may be ar- at. Then the motion of planets and music of the spheres ɔe neglected for a while in admiration of the maze in which .ny atoms run."

en before this was written some of the anticipated results ɔeen partially attained. Loschmidt in Vienna had shown, ɪot much later Stoney independently in England showed, to deduce from Clausius and Maxwell's kinetic theory of a superior limit to the number of atoms in a given meas- .e space. I was unfortunately quite unaware of what ɪmidt and Stoney had done when I made a similar esti- on the same foundation, and communicated it to *Nature*, article 'On the size of atoms.' But questions of personal ity, however interesting they may be to the persons con- d, sink into insignificance in the prospect of any gain of ɜr insight into the secrets of nature. The triple coincidence lependent reasoning in this case is valuable as confirmation conclusion violently contravening ideas and opinions ı had been almost universally held regarding the dimen- of the molecular structure of matter. Chemists and other alists had been in the habit of evading questions as to the

hardness or indivisibility of atoms by virtually assuming them to be infinitely small and infinitely numerous. We must now no longer look upon the atom, with Boscovich, as a mystic point endowed with inertia and the attribute of attracting or repelling other such centers with forces depending upon the intervening distances (a supposition only tolerated with the tacit assumption that the inertia and attraction of each atom is infinitely small and the number of atoms infinitely great), nor can we agree with those who have attributed to the atom occupation of space with infinite hardness and strength (incredible in any finite body); but we must realize it as a piece of matter of measurable dimensions, with shape, motion, and laws of action, intelligible subjects of scientific investigation.

Spectrum Analysis.

The prismatic analysis of light discovered by Newton was estimated by himself as being "the oddest, if not the most considerable, detection which had hitherto been made in the operations of nature."

Had he not been deflected from the subject, he could not have failed to obtain a pure spectrum; but this, with the inevitably consequent discovery of the dark lines, was reserved for the nineteenth century. Our fundamental knowledge of the dark lines is due solely to Fraunhofer. Wollaston saw them, but did not discover them. Brewster labored long and well to perfect the prismatic analysis of sunlight; and his observations on the dark bands produced by the absorption of interposed gases and vapors laid important foundations for the grand superstructure which he scarcely lived to see. Piazzi Smyth, by spectroscopic observation performed on the Peak of Teneriffe, added greatly to our knowledge of the dark lines produced in the solar spectrum by the absorption of our own atmosphere. The prism became an instrument for chemical qualitative analysis in the hands of Fox, Talbot and Herschel, who first showed how through it the old "blowpipe test," or generally the estimation of substances from the colors which they give to flames, can be prosecuted with an accuracy and a discriminating power not to be attained when the color is judged by the unaided eye. But the application of this test to solar and stellar chemistry had never, I believe, been suggested, either directly or indirectly, by any other naturalist, when Stokes taught it to me in Cambridge, at some time prior to the summer of 1852. The observational and experimental foundations on which he built were:—

(1) The discovery by Fraunhofer of a coincidence between his double dark line D of the solar spectrum and a double bright line which he observed in the spectra of ordinary artificial flames.

(2) A very rigorous experimental test of this coincidence by Prof. W. H. Miller, which showed it to be accurate to an astonishing degree of minuteness.

(3) The fact that the yellow light given out when salt is thrown on burning spirit consists almost solely of the two nearly identical qualities which constitute that double bright line

(4) Observations made by Stokes himself, which showed the bright line D to be absent in a candle-flame when the wick was snuffed clean, so as not to project into the luminous envelope, and from an alcohol flame when the spirit was burned in a watch-glass. And,

(5) Foucault's admirable discovery (*L'Institut*, Feb. 7, 1849), that the voltaic arc between charcoal points is "a medium which emits the rays D on its own account, and at the same time absorbs them when they come from another quarter."

The conclusions, theoretical and practical, which Stokes taught me, and which I gave regularly afterwards in my public lectures in the University of Glasgow, were:—

(1) That the double line D, whether bright or dark, is due to vapor of sodium.

(2) That the ultimate atom of sodium is susceptible of regular elastic vibrations, like those of a tuning-fork or of stringed musical instruments; that like an instrument with two strings tuned to approximate unison, or an approximately circular elastic disc, it has two fundamental notes or vibrations of approximately equal pitch; and that the periods of these vibrations are precisely the periods of the two slightly different yellow lights constituting the double bright line D.

(3) That when vapor of sodium is at a high enough temperature to become itself a source of light, each atom executes these two fundamental vibrations simultaneously; and that therefore the light proceeding from it is of the two qualities constituting the double bright line D.

(4) That when vapor of sodium is present in space across which light from another source is propagated, its atoms, according to a well-known general principle of dynamics, are set to vibrate in either or both of those fundamental modes, if some of the incident light is of one or other of their periods, or some of one and some of the other; so that the energy of the waves of those particular qualities of light is converted into thermal vibrations of the medium, and dispersed in all directions, while light of all other qualities, even though very nearly agreeing with them, is transmitted with comparatively no loss.

(5) That Fraunhofer's double dark line D of solar and stellar spectra is due to the presence of vapor of sodium in atmospheres

surrounding the sun and those stars in whose spectra it had been observed.

(6) That other vapors than sodium are to be found in the atmospheres of sun and stars by searching for substances producing in the spectra of artificial flames bright lines coinciding with other dark lines of the solar and stellar spectra than the Fraunhofer line D.

The last of these propositions I felt to be confirmed (it was, perhaps, partly suggested) by a striking and beautiful experiment, admirably adapted for lecture illustrations, due to Foucault, which had been shown to me by M. Duboscque Soleil and the Abbé Moigno, in Paris, in the month of October, 1850. A prism and lenses were arranged to throw upon a screen an approximately pure spectrum of a vertical electric arc between charcoal poles of a powerful battery, the lower one of which was hollowed like a cup. When pieces of copper and pieces of zinc were separately thrown into the cup, the spectrum exhibited, in perfectly definite positions, magnificent well-marked bands of different colors characteristic of the two metals. When a piece of brass, compounded of copper and zinc, was put into the cup, the spectrum showed all the bands, each precisely in the place in which it had been seen when one metal or the other had been used separately.

It is much to be regretted that this great generalization was not published to the world twenty years ago. I say this, not because it is to be regretted that Angström should have the credit of having, in 1853, published independently the statement that "an incandescent gas emits luminous rays of the same refrangibility as those which it can absorb"; or that Balfour Stewart should have been unassisted by it when, coming to the subject from a very different point of view, he made, in his extension of the 'Theory of Exchanges' (*Edin. Transactions*, 1858–59) the still wider generalization that the radiating power of every kind of substance is equal to its absorbing power for every kind of ray; or that Kirchhoff also should have, in 1859, independently discovered the same proposition, and shown its application to solar and stellar chemistry; but because we might now be in possession of the inconceivable riches of astronomical results which we expect from the next ten years' investigation by spectrum analysis, had Stokes given his theory to the world when it first occurred to him.

To Kirchhoff belongs, I believe, solely the great credit of having first actually sought for and found other metals than sodium in the sun by the method of spectrum analysis. His publication of October, 1859, inaugurated the practice of solar and stellar chemistry, and gave spectrum analysis an impulse to which in a great measure is due its splendidly successful cul-

ivation by the labors of many able investigators within the last en years.

To prodigious and wearing toil of Kirchhoff himself, and of Angström, we owe large-scale maps of the solar spectrum, incomparably superior in minuteness and accuracy of delineation o anything ever attempted previously. These maps now contitute the standards of reference for all workers in the field. Plücker and Hittorf opened ground in advancing the physics of pectrum analysis, and made the important discovery of changes n the spectra of ignited gases produced by changes in the hysical condition of the gas. The scientific value of the meetngs of the British Association is well illustrated by the fact hat it was through conversation with Plücker at the Newcastle neeting that Lockyer was first led into the investigation of the ffects of varied pressure on the quality of the light emitted by glowing gas which he and Frankland have prosecuted with such dmirable success. Scientific wealth tends to accumulation ccording to the law of compound interest. Every addition to nowledge of properties of matter supplies the naturalist with ew instrumental means for discovering and interpreting henomena of nature, which in their turn afford foundations for resh generalizations, bringing gains of permanent value into he great storehouse of philosophy. Thus Frankland, led from bserving the want of brightness of a candle burning in a tent n the summit of Mont Blanc, to scrutinize Davy's theory of lame, discovered that brightness without incandescent solid articles is given to a purely gaseous flame by augmented presure, and that a dense ignited gas gives a spectrum comparable with that of the light from an incandescent solid or liquid. Lockyer joined him; and the two found that every incandescent ubstance gives a continuous spectrum—that an incandescent gas under varied pressure gives bright bars across the continuous spectrum, some of which, from the sharp, hard and fast ines observed where the gas is in a state of extreme attenuaion, broaden out on each side into nebulous bands as the lensity is increased, and are ultimately lost in the continuous pectrum when the condensation is pushed on till the gas ecomes a fluid no longer to be called gaseous. More recently hey have examined the influence of temperature, and have btained results which seem to show that a highly attenuated gas, which at a high temperature gives several bright lines, gives a smaller and smaller number of lines, of sufficient brightess to be visible, when the temperature is lowered, the density eing kept unchanged. I cannot refrain here from remarking ow admirably this beautiful investigation harmonizes with Andrews's great discovery of continuity between the gaseous nd liquid states. Such things make the life-blood of science.

In contemplating them we feel as if led out from narrow waters of scholastic dogma to a refreshing excursion on the broad and deep ocean of truth, where we learn from the wonders we see that there are endlessly more and more glorious wonders still unseen.

Stokes's dynamical theory supplies the key to the philosophy of Frankland and Lockyer's discovery. Any atom of gas, when struck and left to itself, vibrates with perfect purity its fundamental note or notes. In a highly attenuated gas each atom is very rarely in collision with other atoms, and therefore is nearly at all times in a state of true vibration. Hence the spectrum of a highly attenuated gas consists of one or more perfectly sharp, bright lines, with a scarcely perceptible continuous gradation of prismatic color. In denser gas each atom is frequently in collision, but still is for much more time free, in intervals between collisions, than engaged in collision; so that not only is the atom itself thrown sensibly out of tune during a sensible proportion of its whole time, but the confused jangle of vibrations in every variety of period during the actual collision becomes more considerable in its influence. Hence bright lines in the spectrum broaden out somewhat, and the continuous spectrum becomes less faint. In still denser gas each atom may be almost as much time in collision as free, and the spectrum then consists of broad nebulous bands crossing a continuous spectrum of considerable brightness. When the medium is so dense that each atom is always in collision, that is to say, never free from influence of its neighbours, the spectrum will generally be continuous, and may present little or no appearance of bands, or even of maxima of brightness. In this condition the fluid can be no longer regarded as a gas, and we must judge of its relation to the vaporous or liquid states according to the critical conditions discovered by Andrews.

Spectroscopic Research in Astronomy.

While these great investigations of properties of matter were going on, naturalists were not idle with the newly-recognized power of the spectroscope at their service. Chemists soon followed the example of Bunsen in discovering new metals in terrestrial matter by the old blow-pipe and prism test of Fox, Talbot and Herschel. Biologists applied spectrum analysis to animal and vegetable chemistry, and to sanitary investigations. But it is in astronomy that spectroscopic research has been carried on with the greatest activity, and been most richly rewarded with results. The chemist and the astronomer have joined their forces. An astronomical observatory has now appended to it a stock of re-agents such as hitherto was only to be found in the chemical laboratory. A devoted corps of volunteers of all nations, whose motto might well be *Ubique*,

have directed their artillery to every region of the universe. The Sun, the spots on his surface, the corona and the red and yellow prominences seen round him during total eclipses, the moon, the planets, comets, auroras, nebulæ, white stars, yellow stars, red stars, variable and temporary stars, each, tested by the prism, was compelled to show its distinguishing prismatic colours. Rarely before in the history of science has enthusiastic perseverance directed by penetrative genius produced within ten years so brilliant a succession of discoveries. It is not merely the *chemistry* of sun and stars, as first suggested, that is subjected to analysis by the spectroscope. Their whole laws of being are now subjects of direct investigation; and already we have glimpses of their evolutional history through the stupendous power of this most subtle and delicate test. We had only solar and stellar chemistry; we now have solar and stellar physiology.

It is an old idea that the color of a star may be influenced by its motion relatively to the eye of the spectator, so as to be tinged with red if it moves from the earth, or blue if it moves toward the earth. William Allen Miller, Huggins, and Maxwell showed how, by aid of the spectroscope, this idea may be made the foundation of a method of measuring the relative velocity with which a star approaches to or recedes from the earth. The principle is, first to identify, if possible, one or more of the lines in the spectrum of the star, with a line or lines in the spectrum of sodium, or some other terrestrial substance, and then (by observing the star and the artificial light simultaneously by the same spectroscope) to find the difference, if any, between their refrangibilities. From this difference of refrangibility the ratio of the periods of the two lights is calculated, according to data determined by Fraunhofer from comparisons between the positions of the dark lines in the prismatic spectrum and in his own "interference spectrum" (produced by substituting for the prism a fine grating). A first comparatively rough application of the test by Miller and Huggins to a large number of the principal stars of our skies, including Aldebaran, *α* Orionis, *β* Pegasi, Sirius, *α* Lyræ, Capella, Arcturus, Pollux, Castor (which they had observed rather for the chemical purpose than for this), proved that not one of them had so great a velocity as 315 kilomètres per second to or from the earth, which is a *most momentous result in respect to cosmical dynamics.* Afterward Huggins made special observations of the velocity test, and succeeded in making the measurement in one case, that of Sirius, which he then found to be receding from the Earth at a rate of 66 kilomètres per second. This, corrected for the velocity of the Earth at the time of the observation, gave a velocity of Sirius, relatively to the Sun, amount-

ing to 47 kilomètres per second. The minuteness of the difference to be measured, and the smallness of the amount of light, even when the brightest star is observed, render the observation extremely difficult. Still, with such great skill as Mr. Huggins has brought to bear on the investigation, it can scarcely be doubted that velocities of many other stars may be measured. What is now wanted is, certainly not greater skill, perhaps not even more powerful instruments, but *more instruments and more observers.* Lockyer's applications of the velocity test to the relative motions of different gases in the Sun's photosphere, spots, chromosphere, and chromospheric prominences, and his observations of the varying spectra presented by the same substance as it moves from one position to another in the Sun's atmosphere, and his interpretations of these observations, according to the laboratory results of Frankland and himself, go far toward confirming the conviction that in a few years all the marvels of the Sun will be dynamically explained according to known properties of matter.

During six or eight precious minutes of time, spectroscopes have been applied to the solar atmosphere and to the corona seen round the dark disc of the Moon eclipsing the Sun. Some of the wonderful results of such observations, made in India on the occasion of the eclipse of August, 1868, were described by Prof. Stokes in a previous address. Valuable results have, through the liberal assistance given by the British and American Governments, been obtained also from the total eclipse of last December, notwithstanding a generally unfavorable condition of weather. It seems to have been proved that at least some sensible part of the light of the "corona" is a terrestrial atmospheric halo or dispersive reflexion of the light of the glowing hydrogen and "helium" round the Sun. (Frankland and Lockyer find the yellow prominences to give a very decided bright line not far from D, but hitherto not identified with any terrestrial flame. It seems to indicate a new substance, which they propose to call Helium.) I believe I may say, on the present occasion, when preparation must again be made to utilize a total eclipse of the Sun, that the British Association confidently trusts to our Government exercising the same wise liberality as heretofore in the interests of science.

Solar Heat.

The old nebular hypothesis supposes the solar system and other similar systems through the universe which we see at a distance as stars, to have originated in the condensation of fiery nebulous matter. This hypothesis was invented before the discovery of the thermo-dynamics, or the nebulæ would not have been supposed to be fiery; and the idea seems never to have occurred to any of its inventors or early supporters that the

ıatter, the condensation of which they supposed to constitute he Sun and stars, could have been other than fiery in the eginning. Mayer first suggested that the heat of the Sun ıay be due to gravitation; but he supposed meteors falling in o keep always generating the heat which is radiated year by ear from the Sun. Helmholtz, on the other hand, adopting he nebular hypothesis, showed in 1854 that it was not neces-ary to suppose the nebulous matter to have been originally iery, but that mutual gravitation between its parts may have enerated the heat to which the present high temperature of he Sun is due. Further, he made the important observations hat the potential energy of gravitation in the Sun is even now ar from exhausted; but that with further and further shrinking ıore and more heat is to be generated, and that thus we can onceive the Sun even now to possess a sufficient store of nergy to produce heat and light, almost as at present, for seve-al million years of time future. It ought, however, to be dded that this condensation can only follow from cooling, and herefore that Helmholtz's gravitational explanation of future un-heat amounts really to showing that the Sun's thermal apacity is enormously greater, in virtue of the mutual gravita-ion between the parts of so enormous a mass, than the sum of he thermal capacities of separate and smaller bodies of the ame material and same total mass. Reasons for adopting this heory, and the consequences which follow from it, are discussed n an article 'On the Age of the Sun's Heat,' published in *Macmillan's Magazine* for March, 1862.

For a few years Mayer's theory of solar heat had seemed to e probable; but I had been led to regard it as no longer tena-le, because I had been in the first place driven, by considera-ion of the very approximate constancy of the Earth's period f revolution round the Sun for the last 2,000 years, to con-lude that "the principal source, perhaps the sole appreciably ffective source of the Sun-heat, is in bodies circulating round he Sun at present inside of the Earth's orbit;" and because Le errier's researches on the motion of the planet Mercury, though iving evidence of a sensible influence attributable to matter cir-ulating as a great number of small planets within his orbit ound the Sun, showed that the amount of matter that could ossibly be assumed to circulate at any considerable distance om the Sun must be very small; and therefore, "if the me-oric influx taking place at present is enough to produce any ppreciable portion of the heat radiated away, it must be sup-osed to be from matter circulating round the Sun, within very ıort distances of his surface. The density of this meteoric oud would have to be supposed so great that comets could arcely have escaped as comets actually have escaped, showing

no discoverable effects of resistance, after passing his surface within a distance equal to one-eighth of his radius. All things considered, there seems little probability in the hypothesis that solar radiation is compensated to any appreciable degree, by heat generated by meteors falling in, at present; and, as it can be shown that no chemical theory is tenable, it must be concluded as most probable that the Sun is at present merely an incandescent liquid mass cooling."

Thus on purely astronomical grounds was I long ago led to abandon as very improbable the hypothesis that the Sun's heat is supplied dynamically from year to year by the influx of meteors. But now spectrum analysis gives proof finally conclusive against it.

Each meteor circulating round the Sun must fall in along a very gradual spiral path, and before reaching the Sun must have been for a long time exposed to an enormous heating effect from his radiation when very near, and must thus have been driven into vapor before actually falling into the Sun. Thus, if Mayer's hypothesis is correct, friction between vortices of meteoric vapors and the Sun's atmosphere must be the immediate cause of solar heat: and the velocity with which these vapors circulate round equatorial parts of the Sun must amount to 435 kilomètres per second. The spectrum test of velocity applied by Lockyer showed but a twentieth part of this amount as the greatest observed relative velocity between different vapors in the Sun's atmosphere.

At the first Liverpool Meeting of the British Association (1854), in advancing a gravitational theory to account for all the heat, light, and motions of the universe, I urged that the immediately antecedent condition of the matter of which the Sun and planets were formed, not being fiery, could not have been gaseous; but that it probably was solid, and may have been like the meteoric stones which we still so frequently meet with through space. The discovery of Huggins, that the light of the nebulae, so far as hitherto sensible to us, proceeds from incandescent hydrogen and nitrogen gases, and that the heads of comets also give us light of incandescent gas, seems at first sight literally to fulfill that part of the nebular hypothesis to which I had objected. But a solution, which seems to me in the highest degree probable, has been suggested by Tait. He supposes that it may be by ignited gaseous exhalations proceeding from the collision of meteoric stones that nebulae and the heads of comets show themselves to us; and he suggested, at a former meeting of the Association, that experiments should be made for the purpose of applying spectrum analysis to the light which has been observed in gunnery trials, such as those at Shoeburyness, when iron strikes against iron at a great velocity.

but varied by substituting for the iron various solid materials, metallic or stony. Hitherto this suggestion has not been acted upon; but surely it is one the carrying out of which ought to be promoted by the British Association.

Nature of Comets.

Most important steps have been recently made toward the discovery of the nature of comets; establishing with nothing short of certainty the truth of a hypothesis which had long appeared to me probable,—that they consist of groups of meteoric stones; accounting satisfactorily for the light of the nucleus, and giving a simple and rational explanation of phenomena presented by the tails of comets which had been regarded by the greatest astronomers as almost preternaturally marvelous. The meteoric hypothesis to which I have referred remained a mere hypothesis (I do not know that it was ever even published), until, in 1866, Schiaparelli calculated from observations on the August meteors, an orbit for these bodies which he found to agree almost perfectly with the orbit of the great comet of 1862, as calculated by Oppolzer; and so discovered and demonstrated that a comet consists of a group of meteoric stones. Prof. Newton, of Yale College, United States, by examining ancient records, ascertained that in periods of about thirty-three years, since the year 902, there have been exceptionally brilliant displays of the November meteors. It had long been believed that these interesting visitants came from a train of small detached planets circulating round the Sun, all in nearly the same orbit, and constituting a belt analogous to Saturn's ring; and that the reason for the comparatively large number of meteors which we observe annually about the 14th of November is, that at that time the Earth's orbit cuts through the supposed meteoric belt. Prof. Newton concluded from his investigation that there is a denser part of the group of meteors which extends over a portion of the orbit so great as to occupy about one-tenth or one-fifteenth of the periodic time in passing any particular point, and gave a choice of five different periods for the revolution of this meteoric stream round the Sun, any one of which would satisfy his statistical result. He further concluded that the line of nodes, that is to say, the line in which the plane of the meteoric belt cuts the plane of the Earth's orbit, has a progressive sidereal motion of about $52''\cdot 4$ per annum. Here, then, was a splendid problem for the physical astronomer; and, happily, one well qualified for the task took it up. Adams, by the application of a beautiful method invented by Gauss, found that of the five periods allowed by Newton just one permitted the motion of the line of nodes to be explained by the disturbing influence of Jupiter, Saturn, and other planets. The period chosen on these grounds is 33¼

years. The investigation showed further that the form of the orbit is a long ellipse, giving for the shortest distance from the Sun 145 million kilomèters, and for longest distance 2,895 million kilomèters. Adams also worked out the longitude of the perihelion and the inclination of the orbit's plane to the plane of the ecliptic. The orbit which he thus found agreed so closely with that of Temple's Comet I, 1866, that he was able to identify the comet and the meteoric belt.* The same conclusion had been pointed out a few weeks earlier by Schiaparelli, from calculations by himself, on the data supplied by direct observations on the meteors, and independently by Peters, from calculations by Leverrier on the same foundation. It is, therefore, thoroughly established that Temple's Comet I, 1866, consists of an elliptic train of minute planets, of which a few thousands or millions fall to the earth annually about the 14th of November, when we cross their track. We have probably not yet passed through the very nucleus or densest part; but thirteen times, in Octobers and Novembers, from October 13, A. D. 902, to November 14, 1866, inclusive (this last time having been correctly predicted by Prof. Newton), we have passed through a part of the belt greatly denser than the average. The densest part of the train, when near enough to us, is visible as the head of the comet. This astounding result, taken along with Huggins's spectroscopic observations on the light of the heads and tails of comets, confirms most strikingly Tait's theory of comets, to which I have already referred; according to which the comet, a group of meteoric stones, is self-luminous in its nucleus, on account of collisions among its constitutents, while its "tail" is merely a portion of the less dense part of the train illuminated by sunlight, and visible or invisible to us

* Signor Schiaparelli, Director of the Observatory of Milan, who, in a letter dated 31st of December, 1866, pointed out that the elements of the orbit of the *August* meteors, calculated from the observed position of their radiant point on the supposition of the orbit being a very elongated ellipse, agreed very closely with those of the orbit of Comet II, 1862, calculated by Dr. Oppolzer. In the same letter Schiaparelli gives elements of the orbit of the November meteors, but these were not sufficiently accurate to enable him to identify the orbit with that of any known comet. On the 21st of January, 1867, M. Leverrier gave more accurate elements of the orbit of the November meteors, and in the *Astronomische Nachrichten* of January 9, Mr. C. F. W. Peters, of Altona, pointed out that these elements closely agreed with those of Temple's Comets (I, 1866), calculated by Dr. Oppolzer, and on February 2, Schiaparelli, having re-calculated the elements of the orbit of the meteors, himself noticed the same agreement. Adams arrived quite independently at the conclusion that the orbit of 33¼ years period is the one which *must* be chosen, out of the five indicated by Prof. Newton. His calculations were sufficiently advanced before the letters referred to appeared, to show that the other four orbits offered by Newton were inadmissible. But the calculations to be gone through to find the secular motion of the node in such an elongated orbit as that of the meteors, were necessarily very long, so that they were not completed till about March, 1867. They were communicated in that month to the Cambridge Philosophical Society, and in the month following to the Astronomical Society.

according to circumstances, not only of density, degree of illumination, and nearness, but also of tactic arrangement, as of a flock of birds or the edge of a cloud of tobacco smoke! What prodigious difficulties are to be explained, you may judge from two or three sentences which I shall read from Herschel's Astronomy, and from the fact that even Schiaparelli seems still to believe in the repulsion. "There is, beyond question, some profound secret and mystery of nature concerned in the phenomenon of their tails. Perhaps it is not too much to hope that future observation, borrowing every aid from rational speculation, grounded on the progress of physical science generally (especially those branches of it which relate to the ethereal or imponderable elements), may enable us ere long to penetrate this mystery, and to declare whether it is really *matter* in the ordinary acceptation of the term which is projected from their heads with such extraordinary velocity, and if not *impelled*, at least *directed* in its course, by reference to the Sun, as its point of avoidance." "In no respect is the question as to the materiality of the tail more forcibly pressed on us for consideration than in that of the enormous sweep which it makes round the Sun in *perihelio* in a manner of a straight and rigid rod, *in defiance of the law of gravitation*, nay, even *of the received* laws of motion." "The projection of this ray . . . . to so enormous a length, in a single day, conveys an impression of the intensity of the forces acting to produce such a velocity of material transfer through space, such as no other natural phenomenon is capable of exciting. It is clear that *if we have to deal here with matter, such as we conceive it*, viz., *possessing inertia—at all*, it must be under the dominion of forces incomparably more energetic than gravitation, and quite of a different nature."

Think now of the admirable simplicity with which Tait's beautiful "sea-bird analogy," as it has been called, can explain all these phenomena.

Origin of Life.

The essence of science, as is well illustrated by astronomy and cosmical physics, consists in inferring antecedent conditions, and anticipating future evolutions, from phenomena which have actually come under observation. In biology the difficulties of successfully acting up to this ideal are prodigious. The earnest naturalists of the present day are, however, not appalled or paralyzed by them, and are struggling boldly and laboriously to pass out of the mere "Natural History stage" of their study, and bring zoology within the range of Natural Philosophy. A very ancient speculation, still clung to by many naturalists (so much so that I have a choice of modern terms to quote in expressing it) supposes that, under meteorological conditions very different from the present, dead matter may have run together,

or crystallized or fermented into "germs of life," or "organic cells," or "protoplasm." But science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor in the Presidential chair. Careful enough scrutiny has, in every case up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation. I utterly repudiate, as opposed to all philosophical uniformitarianism, the assumption of "different meteorolgical conditions"—that is to say, somewhat different vicissitudes of temperature, pressure, moisture, gaseous atmosphere—to produce or to permit that to take place by force or motion of dead matter alone, which is a direct contravention of what seems to us biological law. I am prepared for the answer, "our code of biological laws is an expression of our ignorance as well as of our knowledge." And I say, yes; search for spontaneous generation out of inorganic materials; let any one not satisfied with the purely negative testimony of which we have now so much against it, throw himself into the inquiry. Such investigations as those of Pasteur, Pouchet, and Bastian are among the most interesting and momentous in the whole range of Natural History, and their results, whether positive or negative, must richly reward the most careful and laborious experimenting. I confess to being deeply impressed by the evidence put before us by Prof. Huxley, and I am ready to adopt, as an article of scientific faith, true through all space and through all time, that life proceeds from life, and from nothing but life.

How, then, did life originate on the earth? Tracing the physical history of the earth backward, on strict dynamical principles, we are brought to a red-hot melted globe, on which no life could exist. Hence, when the earth was first fit for life, there was no living thing on it. There were rocks solid and disintegrated, water, air all round, warmed and illuminated by a brilliant sun, ready to become a garden. Did grass and trees and flowers spring into existence, in all the fullness of ripe beauty, by a fiat of Creative Power? or did vegetation, growing up from seed sown, spread and multiply over the whole earth? Science is bound, by the everlasting law of honor, to face fearlessly every problem which can fairly be presented to it. If a probable solution, consistent with the ordinary course of nature, can be found, we must not invoke an abnormal act of Creative Power. When a lava stream flows down the sides of Vesuvius or Etna it quickly cools and becomes solid; and after a few weeks or years it teems with vegetable and animal life, which for it originated by the transport of seeds and ova

and by the migration of individual living creatures. When a volcanic island springs up from the sea, and after a few years is found clothed with vegetation, we do not hesitate to assume that seeds has been wafted to it through the air, or floated to it on rafts. Is it not possible, and if possible, is it not probable, that the beginning of vegetable life on the earth is to be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth—whence come these fragments? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? This idea is so unacceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteoric stones are fragments which had been broken off from greater masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collision, could not cross and re-cross the Atlantic for thousands of years with immunity from collisions. When two great masses come into collision in space, it is certain that a large part of each is melted; but it seems also quite certain that in many cases a large quantity of *débris* must be shot forth in all directions, much of which may have experienced no greater violence than individual pieces of rock experience in a land-slip or in blasting by gunpowder. Should the time when this earth comes into collision with another body, comparable in dimensions to itself, be when it is still clothed as at present with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might, by what we blindly call *natural* causes, lead to its becoming covered with vegetation. I am fully conscious of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. I have already taxed your patience too severely to allow me to think of discussing any of them on the present occasion. The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific.

From the earth stocked with such vegetation as it could receive meteorically, to the earth teeming with all the endless variety of plants and animals which now inhabit it, the step is

prodigious; yet, according to the doctrine of continuity, most ably laid before the Association by a predecessor in this chair (Mr. Grove), all creatures now living on earth have proceeded by orderly evolution from some such origin. Darwin concludes his great work on 'The Origin of Species' with the following words:—"It is interesting to contemplate an entangled bank clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us." . . . . "There is grandeur in this view of life with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning, endless forms, most beautiful and most wonderful, have been and are being evolved." With the feeling expressed in these two sentences I most cordially sympathize. I have omitted two sentences which come between them, describing briefly the hypothesis of "the origin of species by natural selection," because I have always felt that this hypothesis does not contain the true theory of evolution, if evolution there has been in biology. Sir John Herschel, in expressing a favorable judgment on the hypothesis of zoological evolution, with, however, some reservation in respect to the origin of man, objected to the doctrine of natural selection, that it was too like the Laputan method of making books, and that it did not sufficiently take into account a continually guiding and controlling intelligence. This seems to me a most valuable and instructive criticism. I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Reaction against the frivolities of teleology, such as are to be found, not rarely, in the notes of the learned commentators on Paley's 'Natural Theology,' has, I believe, had a temporary effect in turning attention from the solid and irrefragable argument so well put forward in that excellent old book. But overpoweringly strong proofs of intelligent and benevolent design lie all round us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living beings depend on one ever acting Creator and Ruler.

Art. XXXVII.—*On some new Silurian Crinoids and Shells;* by F. B. Meek.

Dendrocrinus Casei *Meek.*

Compare *Pentacrinite* Christy, 1848; Letters on Geology, Plate II.

Column very distinctly pentagonal, the angles at the connection with the body being continuous with strong ridges passing up the sutures between the basal pieces and to the middle of the subradials. Body pentagonal-obconic, a little wider above than high. Base wider than high, strongly pentagonal, being deeply excavated up the middle of each piece, and very prominent at the lateral sutures; basal pieces wider below than high, pentagonal in form, with the mesial angle above salient, and the superior lateral sloping sides much longer than the lateral. Subradial pieces of moderate size, those seen, hexagonal in form, and all very convex in the middle, from which point they send one strongly elevated ridge to meet others on each of the surrounding plates, and others coming up the sutures between the basals, while on each side of all of these ridges, excepting sometimes those passing to the first radials above, there is usually a smaller, less elevated ridge; the surface of the body being thus divided by these ridges into very profoundly excavated triangular spaces, in the middle of which the corners of the body plates meet. First radial pieces, excepting one on the anal side, larger than the subradials, about as wide as high, with a general pentagonal outline, the upper side being longest and deeply excavated for the reception of the comparatively narrow free radials or arm pieces; one on the right of the anal series, shorter than the others, pentagonal in form, and supporting above another larger radial that is included as a part of the wall of the body, and corresponds with the first radials in the other rays, excepting that it is shorter; all convex and sending a strong ridge to each of the contiguous body plates below, while a number of much smaller ridges pass horizontally across from one to another of these pieces on each side. Arms or free rays, comparatively rather narrow, distinctly rounded on the outer or dorsal side, and composed of transversely oblong pieces that are about twice as wide as long below the first bifurcation; in the first ray on the right of the anal series, bifurcating on the fourth free piece, beyond which they are seen to be long and composed of proportionally narrow pieces; but their mode of bifurcation, if they divide again, and their structure in the other rays, cannot be made out from the specimens at hand. Anal series unknown.

Ventral extension of the body more than four times as long as the latter, and as seen flattened by pressure, of greater breadth; as usual, composed of numerous small equal hexagonal, alternately interlocking pieces, that are strengthened by little oblique costæ so arranged as to present an ascending zigzag appearance. Surface, excepting the strong costæ of the body plates, and the smaller ones of the ventral part, without ornamentation.

Height of body to top of first radials, 0·39 inch, greatest breadth at top, 0·32 inch. Length of incomplete ventral extension, 1·95 inches; breadth of same as flattened, near upper end, 0·65 inch; breadth of arms below the first bifurcation, 0·12 inch.

This beautiful species seems to be a true *Dendrocrinus*, as it can be seen to have two of the primary radials on the right of the anal series, included as a part of the walls of the body, while all its other parts seem to conform to the structure of that group. The differences between *Dendrocrinus* and *Poteriocrinites* are not very great, and it is thought by some that the former should stand only as a subgenus under *Poteriocrinites.* If so, the name of this species when written in full, would be *Poteriocrinites* (*Dendocrinus*) *Casei.* In general appearance it resembles *Palæocrinus angulatus* of Billings, but it differs in having the costæ of its body, in part, with a smaller one on each side; while its column is very much more strongly pentagonal. Of course it also differs in the generic character of having its ventral part extended upward nearly or quite as long as the arms.*

It may be that the species here described is the same figured by Mr. Christy, in his "Letters on Geology," as a Pentacrinite (without a specific name), as it came from the same horizon, and from about the same region of country. It does not, however, agree *exactly* with his figure in details.

The specific name is given in honor of L. B. Case, Esq., of Richmond, Indiana, to whom I am indebted for the use of the finest specimen of it I have seen. I am also under obligations to C. B. Dyer, Esq., of Cincinnati, for the use of two smaller, and nearly as good specimens. Figures of the species, with a full description, will be given in the Ohio Geological Report.

Locality and position.—Mr. Case's specimen was found by him at Richmond, Indiana, in the upper part of the Cincinnati group, and those belonging to Mr. Dyer were found at about the same horizon between Cincinnati and Oxford, Ohio.

Lepocrinites Moorei *Meek*.

Body obovate. Base forming nearly one-fourth the height of the body, its four pieces being about as wide as long, of nearly equal size, and irregularly pentagonal in form, excepting one on the anal side, which is hexagonal. The five pieces of the second range of irregular form and size, two on the anal side being longer than wide, and extending up to form the lower margin of the principal opening, which is moderately large, and placed about one-third the length of the body below the top. Arrangement of the plates above not clearly made out. Pectinated rhombs four, comparatively large, one situated at the suture between one of the basal pieces and the contiguous piece of the next range above, on the anterior side of the body; another on the side to the left of the

* Now, since we know the nature of the vault of *Cyathocrinites* (see Proceed. Phila. Acad., N. Sci., Dec., 1868, p. 324 and 336), it seems to me that *Palæocrinus* cannot stand as a distinct genus from that group.

opening, and arranged with its longer axis directed transversely, on a line with the opening, while the other two are nearly on a line with the right side of the opening, on three plates that corner together, the arrangement being such that their longer axes diverge at right angles upward; in these, 15 to 20 of the little bars may be counted.

Recumbent arms short, or confined mainly to the upper side, one extending down nearly to the opening on the anal side, another to the two rhombs to the right of the opening, a third to that on the left, and the fourth to the anterior side, the direction of all being thus nearly or quite at right angles to each other. Column thick at the base of the body, but tapering rapidly below; as usual, composed of very thin pieces. Surface of body plates marked by distinct radiating lines.

Height of body, 0·46 inch; breadth, about 0·36 inch; thickness of column at its connection with the base, 0·14 inch.

This species seems to agree well with the genus *Lepocrinites* of Conrad, excepting in the very unusual character of having four rhombs, instead of only three. As one of these, however, seems to be merely rudimentary, or in other words, not perforated by little slits, I can scarcely think its presence a generic character.

I believe this is the first example of this group of *Cystidians* that has been found in the Lower Silurian, in this country. It occurs, however, in the upper part of the lower series, where some of the other fossils begin to resemble Upper Silurian types.

It has been proposed to correct the orthography of Mr. Conrad's genus to *Lepadocrinus*, and if this orthography should be adopted, the name of our species would be written *Lepadocrinus* or *Lepadocrinites Moorei.* The most usual custom, however, has been to retain the original orthography of generic names in such cases.

The specific name is given in honor of Prof. Joseph Moore, of ——— College, Richmond, Indiana, to whom I am indebted for the use of the only specimen I have seen.

Locality and position.—Upper part of the Cincinnati group, at Richmond, Indiana.

ANODONTOPSIS ? MILLERI *Meek.*

Shell ovate, rather compressed or only moderately convex, the greatest convexity being a little above and slightly in advance of the middle, extremities more or less narrowly rounded, basal margin longitudinally semi-oval in outline, the most prominent part being near the middle; cardinal margin sloping from the beaks at an angle of 130° to 135° and rounding into the lateral margins; beaks only moderately prominent, somewhat obtuse, and not very convex, placed more than one-third the length of the valves from the anterior end. Surface smooth, or only with obscure lines of growth.

Length of a medium sized adult specimen, 0·83 inch; height, 0·59 inch; convexity, 0·30 to 33 inch.

It is not without considerable doubt that I refer this shell to McCoy's genus *Anodontopsis*, since it does not seem to correspond exactly in its hinge characters to his description of that genus, if I correctly understand him. As the hinge of *Anodontopsis*, however, has not yet been illustrated, and different authors do not always describe the same hinge exactly in the same way, I have concluded to refer our shell, for the present, provisionally to *Anodontopsis*. If a new genus, however, it may be called *Orthodontiscus*.

Prof. McCoy described the hinge of his genus as follows: "hinge line shorter than the shell, with a posterior long slender tooth or cartilage plate extending just below it (double in the right valve), and another similar but shorter one in front of the beaks," and then adds that there is "occasionally one small cardinal tooth beneath the beak."

In the shell here described, the hinge may be characterized as having one rather well defined, subtrigonal, or somewhat obliquely extended cardinal tooth under the beak of the right valve, and a corresponding pit under the beak of the left valve, with sometimes a slight prominence or rudimentary cardinal tooth just in advance of this pit; while of posterior lateral teeth there is in the right valve one long tooth ranging parallel to the cardinal margin, with a parallel furrow above and below it for the reception of two posterior laters in left valve, the lower one of which is more prominent, and the upper merely linear or rudimentary. The furrow between these two posterior lateral teeth of the left valve is well defined, and receives the tooth between the two furrows in the other valve. Below the lower of these furrows on the posterior side of the right valve, there is a very slight marginal ridge, that may sometimes assume the character of a second posterior lateral, but it is most prominent anteriorly, where it connects with the cardinal tooth, of which it seems rather to be an oblique posterior prolongation, than a distinct tooth. On the anterior side, there is one shorter anterior lateral tooth in the right valve, also ranging parallel to the hinge margin, and above and below this a little furrow for the reception of two small anterior laterals in the left valve, which receive between them that of the right valve.

The pallial line is certainly simple, and the muscular impressions well defined, the posterior one being larger than the other, and provided with a small accessory scar above just under the posterior ends of the posterior lateral teeth. The ligament or cartilage was probably small and internal, as there are no traces of an external ligament to be seen, the valves fitting close all along the hinge margin. No lunule or escutcheon is to be seen in any of the specimens.*

The specific name is given in honor of S. A. Miller, Esq., of Cincinnati, Ohio, who sent on to the Smithsonian Institute the first

* From all of the known characters of such extinct shells as this, I would be inclined to refer them to the family *Crassatellidæ*, instead of to the *Mytilidæ*, with which Prof. McCoy associates *Anodontopsis*.

specimens of this shell I have seen. I am also indebted to him for some broken valves showing the hinge. For the use of a good specimen showing the hinge of the left valve I am likewise under obligations to C. B. Dyer, Esq., of Cincinnati.

Locality and position.—Forty miles west of Cincinnati, Ohio, above the middle of the Cincinnati group, of the Lower Silurian.

ANODONTOPSIS ? UNIONOIDES *Meek.*

This species has at least all the external characters of the genus, including the last, but nothing is known of the nature of its hinge. Specifically it differs from the species *Milleri*, not only in being very much larger than the adult size of that shell, but in having its anterior outline more regularly rounded, and its posterior obliquely subtruncated above, and with its most prominent part below the middle. Its ventral margin is also much straighter in outline; while its beaks are more depressed and placed decidedly nearer the anterior side, and its dorsal margin is not declining on the posterior side of the beaks as in the last. It likewise differs in having its posterior umbonal slopes more convex on a line from the beaks to the posterior basal margin.

Length, 1·73 inches; height, 1·11 inches; convexity, 0·63 inch.

Locality and position, same as last. The only specimen I have seen was kindly loaned to me for description and illustration, by Mr. S. A. Miller, of Cincinnati.

Remarks on the genus Lichenocrinus; by F. B. MEEK.

Perhaps of all the remarkable types of that protean order of animals known as the *Crinoidea*, there are few more curious and interesting forms (if really the *body* of a Crinoid) than that for which Prof. Hall proposed the name *Lichenocrinus.* Having recently had an opportunity to examine an extensive series of specimens belonging to both of the known species of this type, in the collections of Mr. C. B. Dyer and other gentlemen of Cincinnati, I propose to make a few remarks on the same, that may be of some interest to paleontologists, especially as this fossil is little known, and the specimens now obtained afford the means of giving a more extended description of its characters than that already published.

Prof. Hall's generic description of this crinoid reads as follows: "Bodies parasitic on shells and other foreign substances. Form discoid or depressed-convex, with a proboscidiform appendage rising from the centre. Disk composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate, and in the known species, formed of five ranges of short plates alternating and interlocking at the margins."

From the specimens now known, the following more extended description of this fossil may be given:

Discoid or depressed-plano-convex bodies, growing firmly attached to shells, corals, trilobites and other marine objects, and

entirely destitute of free or recumbent arms or pinnulæ, ambulacral openings or pectinated rhombs. Free or convex side, concave in the central region, and composed of numerous small, non-imbricating polygonal plates, without any definite arrangement; mesial depression provided with a very long, slender, perforated, flexible column-like appendage, composed of five longitudinal series of short, alternately interlocking pieces. Attached side, when separated, presenting no sutures or openings, but in some conditions, showing numerous, distinct regularly arranged, radiating striæ, corresponding to radiating lamellæ that occupy the whole internal cavity from top to bottom.

Among the more remarkable features of this fossil, may be mentioned its very curious system of radiating lamellæ occupying the whole internal cavity, and giving it, when the plates of the upper side are removed so as to expose these lamellæ in place and attached to the adhering side, almost exactly the appearance of the little fungioid coral *Microbacia*. The entire absence, so far as known, of free or recumbent arms or pinnulæ, as well as of the most minute ambulacral or other openings, save the minute perforation into the slender column-like appendage; and the attachment of this appendage to the free side of the firmly adhering disk, are also very anomalous features, if we view this disk as the body of a crinoid.

On examining one of these fossils, one of the first questions that suggests itself is, what can be the nature of this long slender appendage, not more than four to eight or ten hundredths of an inch in diameter, and several inches in length? Is it homologous with the so-called proboscis or ventral tube of other crinoids, or with the column of the same? Prof. Hall evidently entertained the former opinion at the time he wrote the diagnosis quoted above, though I was informed at Cincinnati, that after seeing other specimens than those from which his diagnosis was written, he inclined to the opinion that it is a column. That one or the other of these views is correct, would almost necessarily seem to be the case, and yet there would appear to be rather strong objections to both of these conclusions, if we view the disk as the body of a crinoid. In the first place, if a column, why should the body, instead of being, as usual, attached by it, be always (when not accidentally detached) found growing firmly by the whole opposite side to foreign bodies, and this long appendage in all cases be left dangling free, and if viewed as a column, apparently useless? Again, if a column, connected with the free side of the body of an attached crinoid, how are we to account for the fact that no traces of any other opening than that passing in through this appendage can be seen, even by a careful examination under a magnifier, in any part of the body? In addition to this, it does not connect with the disk by a series of basal pieces, as is usually the case with the connection of the column of a crinoid or cystoid to the body of the same, but on the contrary, the plates of the disk diminish in size inward, and pass by easy gradations into those forming the base of this long appendage.

On the other hand, if we proceed to view this appendage as a proboscis, or ventral tube, connecting with the ventral side of the body, we are met by the objection of its extreme proportional length, slenderness, flexibility, and the fact that it seems to taper off nearly to a point at its free end. In Mr. Dyer's collection there is a piece, apparently of the free end of this organ, about an inch in length, and agreeing exactly in size, form and structure, with that of *L. Dyeri*, that is broken at one end, and tapers to a slightly blunted point at the other end, which is composed of very minute pieces drawn together. In other examples, where three or four inches in length of this appendage can be seen attached to the disk at one end, it tapers off until it becomes exceedingly slender at the free broken end. This character of its termination, especially when viewed in connection with its length, slenderness and other characters, would seem to be a strong objection to the conclusion that it is a ventral tube or proboscis. Still there might have been a minute opening at the extremity, closed by diminutive pieces, as we often see is the case with the opening of much larger crinoids.

While examining the specimens of this type, several solutions of the mystery of its structure suggested themselves, the first one of which was, that possibly the disk, viewed as the body, might really be only a peculiarly constructed root, or base of attachment of a crinoid, the body of which grew at the free end of the long column-like appendage. This suggestion derives some support from the fact that the disk, although usually growing on the flat surfaces of shells, etc., is sometimes found growing upon the side of the columns of other larger crinoids, as well as on other uneven surfaces, and in such cases, it is bent around to conform to the curve of the surface of attachment, just as we see in crinoid roots similarly situated; while its whole interior is so filled with radiating lamellæ, as to leave extremely little, if any, space for the viscera of an animal, and is, as already stated, apparently hermetically sealed, excepting the minute canal leading up into the long appendage. It is true that the roôts of crinoids are generally formed of thickened and anchylosed rings or segments of the column, but Mr. Billings has figured the root of one type (*Cleiocrinus grandis*), apparently composed of an accidentally folded expansion of minute polygonal plates; and it is worthy of note, that the column attached to this root is longitudinally divided by five sutures. It is also true, that there is no example, so far as known to the writer, of any such system of radiated lamellæ being connected with the root of a crinoid; but this objection would doubtless apply with even greater force against the conclusion that this disk is the body of one of these animals.

On the other hand, among the strong objections to the suggestion that these disks are roots, may be mentioned their very regular symmetrical form, and the fact that no indications of a body at the free end of the column-like appendage have yet been observed, nor of a detached body with adhering portions of a col-

umn agreeing with this; while no free criniod that might have been attached to this column in its early stages of growth, is known in these rocks. In addition to this, the tapering and pointed extremity of this appendage would seem to render it at least improbable that it had ever supported a body at that end.

Two other solutions of the difficulty suggest themselves, one of which is, that possibly the specimens, as we now see them, may not be the mature condition of the animal, but only one of the stages of development of some Crinoid, which, if known in its adult condition, is supposed to be an entirely distinct type. The other is that the disks, as we now see them growing fast to other bodies, may be the adult condition of a Crinoid that in its earlier stages of growth was supported on its little column, as in other types, being otherwise free, and that at a later period of its growth, the column became free at its lower end, and was, for a time, trailed about by the floating body, which finally inverted itself and grew fast to other objects by what was originally its vault. The fact, however, that these disks attain a diameter of at least half an inch, with the elongated appendage four inches or more in length, would, even, if known analogies supported such a view, seem to be a very strong objection to the conclusion that these are immature, or embryonic forms; while to say nothing of other strong objections that naturally present themselves against the last mentioned suggestion, the occurrence of these disks of all sizes, from the largest down to others less than a tenth of an inch in diameter, all alike growing fast to other bodies by the side opposite the column-like appendage, seems to demonstrate that this is their mode of growth from the first.*

In view of all that is now known of this curious fossil, it seems to me, without undertaking to express a positive opinion on the subject, that the weight of evidence (supposing that these disks are really the *body* of the crinoid) favors the conclusion that the long appendage is a ventral tube; but *if the appendage is a column*, then I should incline to the opinion that the disk is a peculiarly organized root, and that the body may be yet unknown, unless as an entirely distinct crinoid.

For the use of specimens of this fossil, I am under obligations to Mr. C. B. Dyer, Mr. U. P. James, Mr. D. H. Shaffer, Dr. H. H. Hill and Dr. R. M. Byrnes, of Cincinnati. Mr. Dyer's collection, however, contains much the most complete and instructive series. Full illustrations, showing all of its known characters, will be prepared for the reports of the Ohio Geological Survey. The two known species, *L. Dyeri* and *L. crateriformis*, occur in the Cincinnati group of the Lower Silurian, near Cincinnati, Ohio.

* In a few very rare cases, the disk has been found detached, and showing the flat side marked by very regular radiating striæ. It is almost certain, however, from the fact that hundreds of specimens have been found growing firmly to other bodies, that these few separated individuals had become detached by the disintegration of the object upon which they grew, and that the radiating striæ are only the edges of the lamellæ within, exposed by weathering, as we also sometimes see on the upper side of weathered specimens.

ART. XXXVIII.—*Discovery of a new Planet, and the Elements of the* 114*th Asteroid;* by Dr. C. H. F. PETERS. (From a letter to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, Oneida Co., N. Y., September 11, 1871).

ON the night of the 8th inst. a new planet was found, which probably will receive the number (116) of the asteroid group. The weather has favored me, and I have obtained the three following observations:—

	Ham. Coll. m. t.	A.R. (116).	Decl. (116).
1871, Sept. 8.	$15^h\ 33^m\ 34^s$	$0^h\ 14^m\ 6{\cdot}5^s$	$-3°\ 44'\ 38''$
9.	11 47 31	0 13 30·3	−3 48 48
10.	12 38 3	0 12 41·7	−3 54 12

These positions may be slightly modified by adopting more correct places of the stars of comparison. The planet is somewhat brighter than 11th magnitude.

Of the 114th asteroid (which has been named *Cassandra*), I have computed the following elements, from observations of July 28, Aug. 8 and 18:—

Epoch: 1871, Jan. 0. Berlin m. t.

$$\begin{aligned} M_0 &= 118°\ \ 5'\ 1''{\cdot}84 \\ \pi &= 148\ \ 29\ \ 23{\cdot}1 \\ \Omega &= 163\ \ 53\ \ 32{\cdot}3 \\ i &= 5\ \ 1\ \ 30{\cdot}05 \end{aligned} \left.\vphantom{\begin{aligned}a\\b\\c\\d\end{aligned}}\right\} \text{Mean Equ. 1871, 0.}$$

$$\begin{aligned} \varphi &= 8\ \ 51\ \ 32{\cdot}14 \\ \mu &= 817''{\cdot}54 \\ \log a &= 0{\cdot}4249978. \end{aligned}$$

These represent an observation of Sept. 9 to within a few seconds, and therefore must be very nearly accurate. From them we learn, further, that the planet is really not so very small, but only appeared so in its present opposition. For, we find that it is now in the remoter part of its orbit, near its aphelion.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *Researches in Electricity:—Inaugural-Dissertation for the attainment of the Degree of Doctor of Philosophy at the Georg-August-University, Göttingen;* by THOS. R. BAKER, of Pennsylvania, U. S. A.—The prominent part of these researches was the comparison of the spark length of a given quantity of electricity with its density, and also the spark length with the quantity itself. The apparatus used was the Lane discharging jar, the sinus electrometer of R. Kohlrauscb, and a large multiplicator

employed by Professors Weber and R. Kohlrausch in their determination of the magnetic and mechanical units of electricity. The sinus electrometer is an apparatus by which the density of electricity is determined by the efforts of a charged magnetic needle (a small magnet) against the horizontal intensity of the earth's magnetism. By means of the multiplicator, the quantity of electricity is estimated by measuring the influence of a current many times multiplied upon a small magnet within it.

The jar and electrometer combined were used for the first part of the investigation. The apparatus was charged, and then by means of a micrometer the negative was made to approach the positive ball of the jar until the spark appeared, and at this instant the position of the needle was noted.

The jar combined with the multiplicator served for the second part of the investigation. The balls of the jar were placed at fixed distances apart; and then the electrical machine, also connected with the apparatus, turned until the appearance of the spark.

The examination of the relation was made by seeking the straight line or curve whose equation the expressions for the elements of comparison in question regarded as coördinates most nearly satisfied.

From the results obtained it is concluded that the relations sought in both parts of the investigation most nearly approach that of the coördinates of the hyperbola, though that relation is not presented as *clearly the physical* law in the case.

The relation of the electrical condition of the atmosphere to its moisture, temperature and pressure, and the effect of motion upon the escape of electricity from the needle, were investigated at the same time. In the latter it was shown that the needle when in motion lost its electrical charge considerably sooner than when at rest.

Millersville, Pa., Aug. 14th 1871.

2. *Water unfrozen at a temperature of* $-18°$ *C.*—Boussingault finds that by preventing the dilatation of water, it may be kept unfrozen down to $-18°$ C. He experimented with a gun barrel of steel, into which a steel ball was dropped before filling it with water. During the cold days of December 26, 27 and 30, last, the temperature fell to $-12°$ and $-18°$, and yet on shaking the tube the ball was found to move freely, showing that the water was not frozen.—*L'Institut, July* 12.

II. Geology and Natural History.

1. *Glaciers.*—Canon Moseley has a paper entitled, "On the Mechanical impossibility of the descent of glaciers by their weight alone," in the Philosophical Magazine for August.

2. *Time of the Glacial epoch.*—Lieut.-Col. Drayson in discussing before the Geological Society the "probable cause, date and duration of the Glacial epoch," starts from the fact that the pole of the ecliptic would be the center of polar motion as the pole

ied its distance from that center. He indicated the curve which pole did trace, and this curve was such as to give for the date 000 B. C., a climate very cold in winter, and very hot in summ-r, for each hemisphere; the duration of the glacial epoch he ›d at about 16,000 years. He stated that the calculation result-from this movement agreed accurately with observation.—*Phil. ıg. Aug.*, 1871.

ı. *Das Elbthalgebirge in Sachsen*, von Dr. HANNS BRUNO ɪɴɪᴛᴢ. 1st Part. I. The Sea Sponges of the Lower Quader. pp. 4to. with 10 plates. Cassel, 1871. (Theodor Fischer).—is valuable memoir by Dr. Geinitz notices or describes and nirably figures the following sponges: *Spongia Saxonica* Gein., *ibrospongia subreticulata* Münster in litt., *Cr. isopleura* Reuss, . *heteromorpha* Reuss, *Cr. bifrons* Reuss, *Plocoscyphia pertusa* in., *Amorphospongia vola* Michelin, *Sparsispongia varians* de om., *Tremospongia* (d'Orb.) *pulvinaria* Goldf. sp., *Tr. rugosa* ldf. sp., *Tr. Klieni* Gein., *Cupulospongia* (d'Orb.) *infundibuli-mis* Goldf. sp., *C. Roemeri* Gein., *Stellispongia Plauensis* in., *St. Reussi* Gein., *St. Goldfussiana* Gein.., *St. Michelini* in., *Epitheles* (de From.) *tetragona* Goldf. sp., *E. foraminosa* , *E. robusta* Gein., *E. furcata* Goldf. sp., *Cherendopora undu-a* Mich., *Ch. pateræformis* Mich., *Elamostoma* (de From.), *rmanianum* d'Orb. sp., *El. consobrinum* id. *Siphonia pirifor-s* Goldf., *S. annulata* Gein., *S. bovista* Gein. The memoir is a ·y important contribution to this department of paleontology.

ı. *Sieboldtia Davidiana.*—M. Blanchard has described under s name a large Salamander from the north of China, which pears to be different from that of Japan.—*L'Institut, July* 12.

5. *Bivalve Crustaceans.*—A paper on recent Ostracoids, bivalve ıstaceans, from the Gulf of St. Lawrence, by G. S. Brady, contained in the Canadian Naturalist, No. 4 of Vol. V. It ludes notices of 29 species, 5 of which are illustrated by 13 ures.

3. *On the early stages of Terebratulina septentrionalis*, by ᴡᴀʀᴅ S. MORSE, Ph.D. 12 pp. 4to, with two plates. A paper owing careful research, from the Memoirs of the Boston Society Natural History, Vol. II, Part I, No. II.

7. *Glacier Scratches along valleys.* (Appendix to Art. XXXII.) Prof. Emmons, in his N. Y. Geological Report (1842) at page 2, says that the direction of the glacier scratches in northeastern ›w York "conforms to that of the great valleys; in the Cham-ıin valley it is north and south; in the St. Lawrence valley, ıthwest." The particular localities where his observations were ıde are not mentioned. He describes deep and broad channel-gs of the Trenton limestone west of Watertown, on Black River, ıich have a southwest course, and extending to the shore of ke Ontario, a distance of ten miles; and states that the scorings the rocks are parallel to the valleys, which here run southwest. nong western observations on this point not published in this urnal, are those of Prof. C. A. White in his Iowa Report, and ›se of Dr. Newberry.

8. *Anthers of Parnassia.*—In the Journal of the Linnean Society, vol. xi, Mr. A. W. Bennett published, two or three years ago, an interesting article upon *Parnassia*, its structure, affinities, and its mode of fertilization. I am now to remark only upon its anthers, which are generally described as extrorse. Mr. Bennett, observing that the present writer, in the Genera of North American Plants Illustrated, describes the anthers as introrse, and gives a drawing of *P. Caroliniana* as an illustration, proceeds to say: "I do not, however, find any other observer to agree with Professor Gray's observation in this respect, except two American botanists, Dr. Torrey and Mr. Chapman, who have probably borrowed their descriptions from him; nor do any specimens which I have been able to examine of this species confirm any departure in this respect from the ordinary type of the genus."

It is easy to show that Dr. Torrey's observation, at least, is independent and original. In his Flora of Northern and Middle States, published in 1824, p. 326, he described the anthers of *P. Caroliniana* as "incumbent;" in his New York State Flora, 1843, as "fixed by the base, introrse." The first volume of the Genera N. Amer. Illustrated appeared in 1848. This season I have, for the first time, had the good fortune to see both *P. palustris* and *P. Caroliniana* in flower, in the Botanic Garden of Harvard University, the former blossoming at the beginning, the latter at the close of August. The difference between the two species "in this respect" is obvious.

In *P. palustris*, the anthers are certainly extrorse as to insertion; but the line of dehiscence lateral, with introrse rather than extrorse tendency.

In *P. Caroliniana*, the anthers are quite as much introrse as extrorse as to insertion, and truly introrse for dehiscence. A transverse section removes all doubt, showing the connective or solid part to be posterior, and the anther to be as truly introrse as possible. A. G.

9. *Journal of the Linnean Society* (*Botany*), No. 65, commencing the 13th volume, contains several papers of some interest. Dr. Hance, of Canton, has discovered and describes the plant the root of which is the Lesser Galingal, an export from southern China. He makes it a new species of *Alpinia*, *A. officinarum* Hance, but very near Roxburgh's *A. calcarata*. It appears that the export of it is increasing: 112,000 pounds, valued at £478, left China in the year 1867; nearly 178,000 pounds in 1868; and 370,800 pounds, valued at £3047, in 1869. Dr. Hance also contributes an article on the Chinese Silk-worm Oaks: he concludes "that all circumstances would seem to conspire to render the culture of the oak silk-worm in Europe a sure matter of success, if properly set on foot and fostered." Mr. Hanbury contributes Historical Notes on the *Radix Galangæ* of Pharmacy; from which it appears that its introduction into Europe was due to the Arabs. Although the drug has lost the important place which it once held in medicine, being merely an aromatic stimulant, which might take the place of ginger, yet it is still largely consumed,

especially in Russia, where it is used for flavoring the *liqueur* called *nastvika*, as a cattle-medicine, and by the Tartars it is taken with tea.

Dr. Masters gives a Note on the Genus *Byrsanthus* Guill., and its floral conformation, suggesting an explanation of the singular arrangement of the glands and stamens, and indicating that two species have been confounded.

Rev. S. Matier discourses on Tamil Popular Names of Plants.

The brothers Tulasne contribute New Notes upon the *Tremellineous Fungi* and their Analogues, dating from the Western Coast of France in December last.

Mr. Neale contributes from S. Africa four papers, three of them upon certain Orchids and their Fertilization, and one upon the mode in which certain *Asclepiadeæ* are fertilized. The details are curious, but can hardly be condensed into an abstract.

Mr. Bentham, President of the Society, concludes the number with his paper on the styles of Australian *Proteaceæ;* illustrated by two plates. The flowers, seemingly arranged for self-fertilization, are really adapted for crossing, in some by a sort of dichogamy, the stigma being immature at the time when the pullen is deposited just around it; in others the stigma is curiously and variously protected or kept out of the way of the anthers (sometimes through the agency of a castrated stamen) until after the pallen of that flower is all shed. A. G.

III. Miscellaneous Scientific Intelligence.

1. *Twentieth Meeting of the American Association for the Advancement of Science, held at Indianapolis, Indiana, August* 16–21, 1871.—The satisfactory result of the Chicago meeting of the American Association in 1868, had, no doubt, its influence in deciding the choice of Indianapolis as the place for holding the recent session. The result seems on the whole to have justified the expectations of those who advocated the claims of the capital of the State of Indiana for this annual Congress of Science. The number in attendance is stated to have been about 200, or about the same as at Troy, Salem, and Chicago. The titles of papers entered are fewer, having been 78, against 143 at Troy, and 150 each at Salem and Chicago.

The Indianapolis meeting, under the presidency of Dr. Asa Gray of Cambridge, appears to have given much satisfaction to those present, among whom were many distinguished workers in science. His Excellency Governor Baker welcomed the Association to the hospitalities of Indianapolis and of the State of Indiana in a cordial opening speech, to which the retiring President, Dr. T. Sterry Hunt, replied in his usual appropriate and graceful manner.

The formal address of the retiring President was delivered on the evening of the first day, before a large audience. Its subject, "The Geognosy of the Appalachians and the origin of Crystalline Rocks," and its general scope, are stated on page 205.

An interesting feature of the Indianapolis meeting was an excursion on a grand scale to the coal fields of Indiana. The excursionists, numbering over four hundred, were carried in eight coaches. They visited at Knightsville the iron furnaces of the Watson Brothers, where they were sumptuously entertained at luncheon; also three other iron furnaces and several coal mines on the way to the town of Brazil, where they were welcomed by the citizens at Masonic Hall and dined with the usual complimentary addresses on both sides. The recent development of the coal known as block coal, due largely to the intelligent zeal of Prof. E. T. Cox, the State Geologist of Indiana, was the object of greatest scientific interest in the excursion. This coal is used in the raw state in the iron furnaces, and is said to be remarkably free from both sulphur and phosphorus. The excursion rested at Terre Haute, a town of 20,000 inhabitants, which seems to have exhausted every means to render the visit of the Association delightful and profitable. Here they passed the night, holding an evening general session at the Opera House. A popular lecture on the Winged Reptiles was delivered by Mr. A. Waterhouse Hawkins. On the following morning Dr. Gray delivered a lecture on the Fertilization of Flowers by Insects to a delighted audience; and after an early dinner, the party returned by special train to Indianapolis.

An excursion to Mammoth Cave in Kentucky was the closing act of the Association, after the adjournment of the Indianapolis meeting.

The Association, after enjoying the public and private hospitalities of Indianapolis and of the sections of the State included in the excursions, adjourned on the 21st, having voted conditionally to meet in San Francisco, California, in July, 1872, the final decision having been left with the Standing Committee.

The officers chosen for the next meeting are: President, Dr. J. Lawrence Smith, of Louisville, Ky.; Vice-President, Prof. Alex. Winchell, of Ann Arbor, Mich.; Permanent Sec'y, Prof. Joseph Lovering, of Cambridge, Mass.; General Sec'y, Prof. E. S. Morse, of Salem, Mass.; Treasurer, William S. Vaux, of Philadelphia.

The following are the subjects of the papers presented, and of the public lectures:

1. In General Session.

1. On Pterosauria; by B. Waterhouse Hawkins.
2. Fertilization of Flowers by Insect Agency; by Asa Gray.
3. On true Musical Intonation; by J. D. Tillman.
4. The Earthquake of October, 1870; by Charles Whittlesey.
5. On the Iron and Coal Interest of Indiana; by T. Sterry Hunt.
6. An Examination into the Laws of Development of Organic Types; by E. D. Cope.

2. In Section A.—*Mathematics, Physics, and Chemistry.*

1. The Daily Motion of a Brick Tower caused by Solar Heat; by C. G. Rockwood.
2. On the use of the Zenith Telescope for determination of Time; by J. E. Hilgard.

3. On the construction and verification of Metric Standards for the United States; by J. E. Hilgard.
4. Organic Identity of the Albumen and Endopleura of Seeds; by T. C. Hilgard
5. The Influence of the Moon on the Crust of the Earth; by Clinton Roosevelt.
6. On Chemical Equivalents; by S. D. Tillman.
7. On the Transmission of Heat; by S. D. Tillman.
8. The Relation between the Distances and proper Motions of the Stars; by T. H. Safford.
9. On the Earthquake of October, 1870; by Charles Whittlesey.
10. An inquiry concerning the Physical Relations between the Masses and Mean Distances of the Minor Planets; by Daniel Kirkwood.
11. On the Distribution of the Mean Distances of the Minor Planets; by Daniel Kirkwood.
12. Note on the Periodicity of the Solar Spots; by Daniel Kirkwood.
13. On the probable age of Halley's Comet; by Daniel Kirkwood.
14. Longitude Determination across the Continent; by George W. Dean.
15. On the Mutual Action of Electric Currents; by E. B. Elliott.
16. Radiation; by H. F. Walling.
17. The Chemical Equivalent of Æther; by H. F. Walling.
18. The co-relation of Electricity and Chemical Force; by H. F. Walling.
19. On a form of Boomerang in use among the Mogni Puebla Indians of North America; by C. C. Parry.
20. An improvement of Eggertz's Method of determining Carbon in Steel; by L. R. Taylor.
21. The Four Great Eras in Modern Astronomy; by Jacob Ennis.
22. Meteors; by Jacob Ennis.
23. The cause of Stellar Heat and Light; by Jacob Ennis.
24. The Character and Chemical Composition of the Meteorite that fell on May 21, near Searsmont, Maine; by J. Lawrence Smith.
25. A description of the exact locality of the immense masses of Meteoric Iron in Cohahuila, Mexico, with the analysis of one recently discovered; by J. Lawrence Smith.
26. A convenient and certain method of regulating a constant level of Water in the water baths of a Laboratory; by J. Lawrence Smith.
27. Remarks on the Cinnabar and other Minerals from California; by J. Lawrence Smith.
28. A new and ready method of making Platinum black; by J. Lawrence Smith.
29. A ready method of separating the Alkalies, on a large scale, from Lepidolite; by J. Lawrence Smith.
30. A new and convenient Specific Gravity Flask; by J. Lawrence Smith.
31. On the Enharmonic Scale of 31 tones in the octave, and a new practical key-board corresponding with the accepted musical notation; by P. H. Van der Weyde.
32. On Oblique Microscopic Examination, and a new, simple apparatus for the same; by P. H. Van der Weyde.
33. On the use of the Balance for determining the changes in Atmospheric Pressure, and the co-efficient of Barometric Correctness; by P. H. Van der Weyde.
34. On the Invisible Caloric Extreme of the Solar Spectrum, and the non-caloric lines or bands in the same; by P. H. Van der Weyde.
35. On a new and more perfect fire test of illuminating Petroleum, without the use of fire; by P. H. Van der Weyde.
36. An application of an exponential function; by J. E. Hilgard.
37. To find a general formula for the length of "Curves of Pursuit;" by Joseph Ficklin.
38. Steam boiler Water and Incrustation; by Jos. G. Rogers.

3. In Section B.—*Geology and Natural History.*

1. The Monocotyledon the Universal Type of Seeds; by Thomas Meehan.
2. The Classification of Echinoderms from their Microscopic Structure; by Alexander Agassiz.
3. Mechanism of Flexion and Extension in Birds' Wings; by Elliot Coues.

4. On the Morphology of the Osseous System; by T. C. Hilgard.
5. On the Geological History of the Mexican Gulf; by E. W. Hilgard.
6. Observations on the Common Ground Worm; by James J. H. Gregory.
7. Observations on the Geology, Physical Features, and Retrocession of Niagara Falls; by George W. Holley.
8. Some Questions on Surface Geology; by Frank H. Bradley.
9. On the Entozoca peculiar to Swine; by William B. Fletcher.
10. On the Development of the Tarsal and Carpal Bones in Birds; by Edward S. Morse.
11. On the Characteristics of the Primary Groups of the Class of Mammals; by Theodore Gill.
12. On the Natural System of Fishes; by Edward D. Cope.
13. The Embryology of Chrysopa, and its bearings on the classification of the Neuroptera; by A. S. Packard, Jr.
14. On the Eozoon Canadense in the Crystalline Limestones of Massachusetts; by L. S. Burbank.
15. On the relation of Anomia; by Edward S. Morse.
16. Contributions to Physiographic and Dynamical Geology; by Richard Owen.
17. On the apparently one-ranked phyllotaxis of Baptisia perfoliata, and on the phyllotaxis of Cucurbitacea; by Henry W. Ravenel.
18. On the Geology of Northwestern Massachusetts; by Sanborn Tenney.
19. Western Coal Measures and Indiana Coals; by E. T. Cox.
20. Remarks on the Geology of the Mississippi Bottom; E. A. Smith.
21. Account of a Dust Storm which occurred in Clinton county, Indiana, Dec 24, 1870; by Joseph Tingley.
22. Remarks upon the Catskill Red Sandstone Group as it occurs upon the borders of New York and Pennsylvania; by James Hall.
23. Views of Nature: of the Organizing Principle, and of Life and Intellect; by E. C. Seaman.
24. Vitalism, Spiritualism, and Materialism; by E. C. Seaman.
25. The Eozoon Limestone of Eastern Massachusetts; by J. B. Perry.
26. Remarks on the Geological Map and Section of Missouri Rocks; by G. C. Swallow.
27. On the Extinct Tortoises of the New Jersey Cretaceons; by Edward D. Cope.
28. Remark on the Abies Douglassii, and a new species, or a peculiar variety of the Abies balsamifera, of the Rocky Mountains; by G. C. Swallow.
29. Remarks on the Snow Line in the Mountains of Montana; by G. C. Swallow.
30. On the Embryology of Amblystoma lurida of Sager; by P. R. Hoy.

IN SUBSECTION E.—*Archeology and Ethnology.*

1. A Theory on the Nature of the Difference in the Mental Capacity of High and Low Races of Men; by Renas Davis.
2. Note on the Distribution of Population in the United States; by J. E. Hilgard.
3. Rock Inscriptions in Ohio; by Charles Whittlesey.
4. An Ancient Mount on the Etowah River, Georgia; by Charles Whittlesey.

On the rates of interest realized to investors in the Securities of the United States; by E. B. Elliott.

Law:—What is it, and what are its Functions and Limits; by E. C. Seaman.

IN SUBSECTION C.—*Microscopy.*

1. Report on Photographing Histological Preparations by Sunlight; by J. J. Woodward.
2. Remarks on a new form of Achromatic Condenser, applicable to low and medium powers; by E. Bicknell.
3. On a new form of Micro-Telescope; by R. H. Ward.
4. Remarks on recent improvements in Achromatic Condensers; by R. H. Ward.
5. On the use of the Microscope in Chemical Analysis; by P. H. Van der Weyde.
6. On the observation of the Electric Induction Spark by the Micro-Spectroscope.
7. On Oblique Microscopic Illumination, and a new, simple Apparatus for the same; by P. H. Van der Weyde.

8. On some observed changes in Vorticella; by A. H. Tuttle.
9. Remarks on a Standard of Powers for Microscopical Objectives and Eye Pieces; by R. H. Ward.
10. On the Microscopic Structure of Eozoon Canadense; by E. Bicknell.

3. *On the relation of the Auroras to Gravitating Currents;* by PLINY EARLE CHASE, Professor of Physics in Haverford College. (Read before the American Philosophical Society, May 5th, 1871.)—Prof. Loomis's observations of the number of auroras in each month of 1869 and 1870 (Amer. Jour. of Science, III, S., i. 309), are specially noteworthy, both because of the careful accuracy of the observer, and because they are the first published observations which furnish satisfactory data for an approximate determination of the laws of auroral distribution.

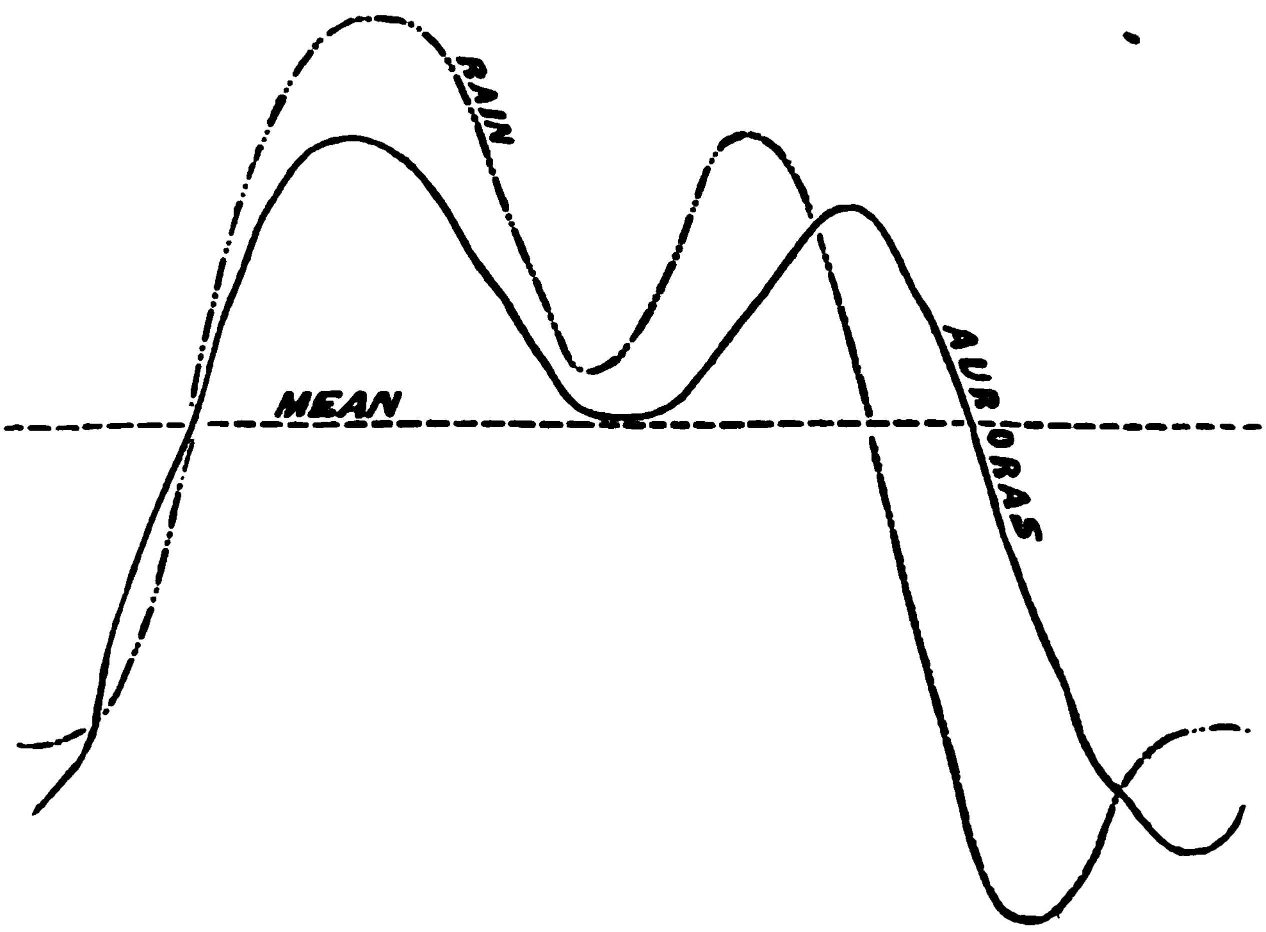
If the auroras are, as is now generally believed, luminous manifestations of terrestrial magnetism, it seems reasonable to look to them for some additional evidence upon the question of the relation between magnetic and gravitating currents. Messrs. Baxendell and Bloxam have already pointed out some resemblances between hyetal and magnetic curves (see Proc. A. P. S., x, 368), and if analogous resemblances can be traced between hyetal and auroral curves, they will be interesting and suggestive.

I have not found the similarity between the annual distribution of rain-falls and of auroras sufficiently striking to impress any one who has not made a special study of the causes of resemblance and difference. But, as I have repeatedly urged, currents are subject to an increased number of disguising disturbances, in proportion to the sluggishness of their motion, and the time which is consequently required for their formation or change. We may very reasonably look for analogies between the daily and the annual auroral or magnetic curves, of a character for which we could hope to find no parallel in wind, rain, or ocean-current curves.

If we desire, therefore, to find evidence of the joint influence of solar expansion and gravitating equilibrium, we should look where it is most likely to be found, and to the best of the observations which may be supposed to be fairly comparable. There are similar variations of solar attitude, and consequently increasing and diminishing solar force, in the day and in the year, but the effects of these variations upon the precipitation of vapor, are more likely to be shown in their greatest simplicity by the means of observations at different hours of the day than at different seasons of the year. I know of no published observations of this character at New Haven, but there are some extending over a long series of years at Philadelphia, and at Greenwich, the curves at each station indicating minima of rainfall at noon and midnight, and maxima in the morning and evening. The difference of longitude between Philadelphia and New Haven being less than $2\frac{1}{2}°$, it is not likely that there is any material difference in the daily rain-curves at the two places.

In order to make the curves fairly comparable, both in regard to the times and the magnitudes of deviation, I treated the auroral

observations in the same manner as those of rainfall (Proc. A. P. S., x, 526). Both in the magnetic and in the hyetal phenomena, the greatest effects accompany the greatest atmospheric changes. But in the magnetic disturbances the principal maxima occur in the spring of the year and the morning of the day, while the general evaporation is increasing, whereas, in the daily rains at Philadelphia, the principal maximum occurs in the afternoon, when evaporation is diminishing. I have, therefore, compared the midwinter ordinate of the auroral with the noon ordinate of the rain curve, and the midsummer auroral with the midnight hyetal ordinate.



The auroral observations and the normal ordinates, of the accompanying curves, are given in the following table. I presume no one will doubt that the condensation of vapor, which is represented by the rain curve, is occasioned by the simple operation of gravitation in blending currents of different temperatures, and I see no reason for postulating any different law for the development of electricity and magnetism in the aurora.

Comparative Table of Auroras and Rainfalls.

Months.	No. of Auroras.	Normals.	Hours.	Normals of Rain.	Months.	No. of Auroras.	Normals.	Hours.	Normals of Rain.
January	32	88	0	91	July	38	100	12	103
		90	1	91			101	13	106
February	31	94	2	93	August	34	103	14	109
		98	3	98			105	15	108
March	41	103	4	105	September	43	107	16	104
		107	5	110			106	17	98
April	44	109	6	113	October	38	103	18	92
		109	7	113			100	19	87
May	36	108	8	112	November	27	95	20	85
		106	9	109			91	21	87
June	31	103	10	105	December	30	89	22	90
		101	11	102			87	23	91

IV. Miscellaneous Bibliography.

1. *War and the Weather, or the Artificial production of Rain;* by Edward Powers, C.E.—The object of this little volume is to show that rain can be produced by human agency, particularly by heavy discharges of artillery; and a large number of cases are cited in which great battles have been followed by speedy rain. Six cases of this kind are cited which occurred during our war with Mexico in 1846 and '47; nine cases of battles or skirmishes are cited which occurred in 1861 in the war of the rebellion, and which were followed by rain at no great interval; forty such cases are cited for 1862; thirty for 1863; twenty-eight for 1864; and six for 1865. Eighteen similar cases are also cited from among the great battles which have occurred in Europe during the past century, making a total of 137 cases. The author thinks that if these facts are insufficient to convince, it would be vain to expect to do so with a greater number of cases.

To this argument it may be replied that throughout the region from which his examples are mainly collected, rain falls upon an average once in three days, and probably a little more frequently; so that from the conclusion of one rain to the commencement of another, the interval is on an average but little over two days. Now battles are not usually commenced during a period of rain; generally not till some hours after the conclusion of a rain. Rain ought then generally to be expected within about one day after the conclusion of a battle. Now the argument of Mr. Powers is lame in this point. He takes no precise account of the length of the interval between the conclusion of a battle and the commencement of rain; nor does he show that this interval is less than it should be if the battle had no influence in the production of the rain; and in particular he takes no account of the cases unfavorable to his theory, in which rain follows a battle only after a very long interval. In order to make the argument complete, a much more careful analysis of the facts is required. It should be determined from a comparison of a large number of cases, including *all* the battles within a particular circuit, what is the average interval between a battle and the next succeeding rain, and it must then be shown that this interval is less than it would be if the battle had no influence in the production of rain.

The simplest mode of making the comparison may be the following: Determine for *all* the battles occurring within a particular circuit what is the average interval between the conclusion of the rain next preceding a battle and the commencement of the rain next following it; and then determine for the same region the average interval between two successive rains when no battle has occurred. If the former interval should be found sensibly less than the latter, it would be reasonable to conclude that the battle had exerted some influence in accelerating the fall of rain. The facts collected by Mr. Powers are not digested in any such manner; and although we are inclined to the opinion that great battles do exert some influence in the production of rain, we do not think

that Mr. Powers has established his proposition in a satisfactory manner.

With regard to the mode in which a heavy discharge of artillery might cause rain, we differ widely in opinion from the author of this book; but we are not fairly called upon to assign a reason *why* artillery firing causes rain until it has been shown that it *does*, at least sometimes, produce such an effect. We should be much pleased if Mr. Powers, or some other person, would resume the discussion of this subject in accordance with a truly scientific method. E. L.

2. *Introductory Text-Book of Meteorology*; by ALEXANDER BUCHAN, M.A., F.R.S.E., Secretary of the Scottish Meteorological Society. 218 pp. 12mo, with 6 plates. Edinburgh and London, 1870. (Wm. Blackwood & Sons).—Mr. Buchan takes the lead among the meteorologists and meteorological investigators of Scotland. This small and convenient text-book takes up in order the history and scope of Meteorology; Atmospheric pressure and its distribution over the globe—a subject which has been much elucidated through Mr. Buchan's labors; modes of observing and calculating temperature; solar and terrestrial radiation; distribution of terrestrial temperature and its relation to atmospheric pressure; moisture of the atmosphere; mists, fogs and clouds; rain, snow and hail; winds; storms; atmospheric electricity; whirlwinds, and waterspouts; aurora borealis and terrestrial magnetism; ozone; optical phenomena; meteors; weather and storm warnings. Six of the plates contain an exhibition for the globe of the isobarometric and isothermal lines; one is a synchronous weather-chart of Europe for 2d Nov., 1863, at 8 A. M., and one a similar chart of the West Indies for 1st Oct., 1866, at 8 P. M.

3. *Dominican Republic. Report of the Commission of Inquiry to Santo Domingo*, with the Introductory Message of the President, Special Reports made to the Commission, State Papers furnished by the Dominican Government, and the statements of over Seventy Witnesses: *Commissioners*, B. F. WADE President, A. D. WHITE, S. G. HOWE; Secretary, A. A. BURTON, Assistant Secretary, F. DOUGLASS. 298 pp. 8vo, with a map of the island. This volume contains reports from the Scientific view of the expedition, W. P. Blake, C. Wright and others. But the time at the island was too short for thorough exploration.

4. *Sun-Pictures of Rocky Mountain Scenery*, with a description of the Geographical and Geological features and some account of the Resources of the great West; containing thirty photographic views along the line of the Pacific Railroad, from Omaha to Sacramento. By F. V. HAYDEN, M.D., U. S. Geologist, Prof. Min. and Geol. in the University of Pennsylvania. 150 pp. 4to. 1870. New York: (Julius Bien). The character of this work has already been stated in this Journal, and citations have been made from its pages of important scientific observations. It is published in elegant style, the paper and printing being of the best kind; and the photographs excellent and highly interesting.

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[THIRD SERIES.]

ART. XXXIX.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE, Prof. Geol. and Nat. Hist., University of California.*

VI. *So-called "images of illusion;" and the theory of binocular relief.*

IN a very elaborate paper on binocular vision published in the Archives des Sciences† for Feb., 1871, which is itself but a succinct resumé of a much more extended memoir soon to be published, M. Pictet undertakes to establish on a firm basis the "*nativistic*" theory which regards *corresponding points* as *congenital* and the result of *anatomical structure*, as opposed to the "*empiristic*" theory which regards them as the *result of experience.* After summing up the usual arguments and objections on each side, he proceeds, as he thinks, to prove the truth of the former theory by showing, first, *a priori*, the consequences which must flow from the admission of this theory; second, that the visual results of certain experiments are precisely what *a priori* reasoning leads us to expect; and third, that this theory, in the form in which he maintains it, explains all the more obvious phenomena of binocular vision.

The one strikingly new thought in M. Pictet's memoir is the supposed existence of "*images of illusion*" in every act of vision. *This* it is which follows, he thinks, from the admission of the nativistic theory; it is *this* which he attempts to prove by all his experiments; it is by means of *this* that he solves all the

* For previous papers on this subject see II, vol. xlvii, pp. 68, 153; III, vol. i, p. 33, and vol. ii, p. 1.

† Arch. des Scien., nouv. per tome xl, p. 105.

vexed questions of binocular vision. Now while I believe the evidence is overwhelmingly in favor of the nativistic theory, i. e., the *congenital* existence of corresponding points, yet I feel perfectly confident that the existence of M. Pictet's images of illusion, from their very nature, cannot be proved; and that all the phenomena which he adduces as proof may be easily explained by the known laws of binocular vision. Passing over, therefore, the many interesting questions touched upon in M. Pictet's very suggestive paper, I will confine myself wholly to M. Pictet's *illusive images;* my sole object being to rescue the theory of binocular vision from the confusion into which it has been thrown by the introduction of this new idea.

In order to account for single vision with two eyes, Muller supposed that the nerve fibers which terminate *peripherally* in identical points of the retinæ (*corresponding fibers*) are *centrally* fused into *one fiber*, or *terminate centrally in one brain cell.* M. Pictet admits that the nativistic theory is by no means dependent on this assumption the existence of corresponding or identical points as a congenital fact, by whatsoever structural contrivance effected, being all that is contemplated by this theory—yet all his reasonings are based upon, and all his experiments are intended to prove, *an alliance* between corresponding fibers *equivalent to* the *fusion* of Müller. For M. Pictet, corresponding fibers under all conceivable circumstances behave *like*, and therefore *are* substantially, a *single bifurcating fiber.* Assuming, then, an anatomical structure equivalent to fusion of corresponding fibers into one in the brain, M. Pictet proceeds to show that, by the well-known physiological law which refers all impressions on the nerve *centers* to the *peripheral extremities of the nerve fibers*, an impression made upon any point of *one retina*, being carried to the brain, would thence be necessarily referred back to *both extremities* of the bifurcating fiber, i. e., *to corresponding points of both retinæ.* Therefore, if luminous rays from an object impress the *retina of one eye*, the impression transmitted to the brain must be referred back *equally to both eyes*, producing *two identical external images* in the field of view; the [illegible] a *true image* produced by the luminous impression on the retina of one eye, the other an "*image of illusion*"—a subjective [illegible] spectral image—*reflected from the point of alliance* within the brain to the *retina of the other eye.* According to M. [illegible] therefore, even *when we shut one eye* we [illegible] *see objects with both eyes;* for there [illegible] the open eye and an illusive [illegible] two images are *identical* and [illegible] effects are not observ[illegible] these two images are [illegible]

is easy to see, from the perfect identity and the inseparable n of the true and illusive images, how difficult, nay, even ssible and therefore futile, to attempt to prove the existence ie latter. Nevertheless, M. Pictet details several experits which, he thinks, prove beyond doubt the existence of illusive images in every act of vision. I wish to show that phenomena of M. Pictet's experiments may be explained out resorting to illusive images. Before doing so, however, d it necessary to state very concisely certain general prins of binocular vision which I shall use in their explanation, ring the reader to my previous papers for a fuller statement proof. Throughout this paper I shall refer back to these ciples by means of the numerals affixed.

The impressions produced by *luminous retinal images* are smitted to the brain and, by a psychological law, are prod outward into the external world and seen there as *exter-images.* Each eye has its *own field of view* crowded with *its images.* As these images are usually seen *double,* it will be convenient to regard them not as *objects* but as external es, the signs of objects. Only when the two images formed he same object are superposed do we see the object *single in its true position.* This takes place when the *lumin*... ges fall on *corresponding points.* The two retinal images ... esponding points are *seen* externally as a *single* image ... ct. It is true this may be regarded as *really a single* ... *sign of the fusion of the nerve fibers.* But since we can ... it the *two* images of the *same* object, bring them near ... er, unite them partly or unite them wholly, as we please; since, moreover, we can even take images of *different* ... superpose them, and if they be similar, unite them ... ar as *one* object, it is better, because it more easily ... al phenomena, to regard single binocular vision as ... *superposition of two images.*

In binocular vision with the optic axis parallel ... at a distant object, the whole field of view and ... field, including the visible parts of the face are ... *right* eye a half ... and ...

Of course, by this shifting of the two fields all objects are similarly doubled.

Thus in binocular vision the two eyes *seem* actually to be superposed and corresponding points to coincide. This apparent combination of the eyes and their visual lines is the necessary result of the existence of corresponding points. Images on corresponding points are seen single; all objects in the two visual lines must impress corresponding points; therefore the visual lines themselves, if they were visible lines, would be seen single. This can take place only by combining to form a single *middle* visual line.

3. In turning the eyes in any direction *without altering their convergence* objects seem stationary, and the visual lines seem to move and sweep over them. But when we turn the two eyes in *opposite directions*, as in strong convergence, then the *visual lines seem stationary* (i. e., we seem to look in the same direction), and *all objects or rather images seem to move in a direction contrary to the actual motion of the eye;* the whole field of view of each eye with all its images rotates about the optic center in a direction contrary to the rotation of the eye. This is plainly seen by voluntarily and strongly converging the eyes upon an imaginary point near at hand, and at the same time watching the movements of the more distant images. The whole field of view of the right eye with all its images will be seen to rotate to the right and of the left eye to the left, i. e., *homonymously.* The images of all objects as they are swept successively by the visual lines of the two eyes are brought successively in front and superposed. If we could turn our eyes outward, the fields and their images would move heteronymously. This is seen to a limited extent in the act of falling to sleep.* Even with the two eyes *turned outward*, therefore, the two visual lines are united *in front*, and objects on the visual lines are brought in front and superposed. This is the necessary result of the properties of corresponding points; but I have also proved it by observations made upon persons whose eyes in a perfectly passive state turned slightly outward.*

Thus, there are two *apparent* movements of the visual fields accomplished by the eyes in binocular vision: 1st, a *shifting* of each field *heteronymously* a half interocular space; this is involuntary and habitual, and would of itself double all objects heteronymously; 2d, in ocular convergence, a *rotation* of each field about the optic center *homonymously.* The necessary consequences of these movements are: (a) that the two images of *an object at the point of sight* are superposed and the object is seen single; objects on *this side* the point of sight are doubled heteronymously, while objects beyond the point of sight are doubled

* The proof of this statement I hope to give shortly in a separate article.

homonymously; (b) that all objects (*different objects*) lying in the visual lines, whether on this side or beyond the point of sight, have two of their images (one of each) superposed; so that the two visual lines *under all circumstances* are combined to form a binocular visual line passing from the combined eyes, through the point of sight, and onward to infinite distance.

Let us now, in the light of these facts, examine M. Pictet's experiments. I will pass over for the present what he seems to regard as his crucial experiments, and take up first the general phenomena of double images, as a proper understanding of the nature of these will make all that follows clear.

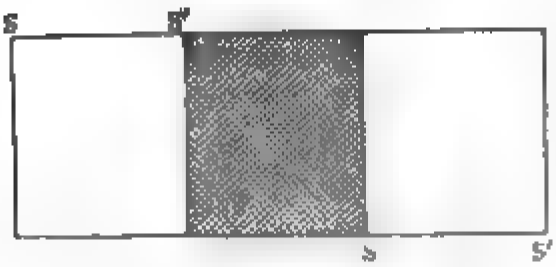
If we hold up a finger before the eyes, and gaze at the wall on the opposite side of the room, two heteronymous images of the finger will be seen separated by a space nearly equal to the interocular space. As a question of geometry this is sufficiently explained by the different parallactic position of the finger as seen by the two eyes; as a question of binocular vision, by the shifting of the fields of view of the two eyes heteronymously as already explained (2).

But the images are *transparent*. M. Pictet lays much stress on this. It is, he says, "an essential point which we have not found in works on optical physiology" (p. 105). He explains it as follows: There is a part of the wall which sends no luminous rays to the right eye (viz: that covered by the right-eye image); but this part impresses the left eye, and this impression is *propagated* to the right eye, and perceived by it at the same place as an *illusive image*. The finger, therefore, will appear transparent to the right eye because by means of an illusive image the wall is seen behind it. The same explanation of course applies to the left-eye image of the finger, which is transparent, according to M. Pictet, because the left eye sees the wall behind it by means of an illusive image propagated from the right eye. Now *our* explanation is entirely different; and we cannot but think that the transparency of double images have been so little noticed by writers only because their explanation seemed so obvious. Our explanation is as follows: We see *every* part of the wall because *no* part is concealed from *both* eyes. The images must seem transparent since they conceal nothing from *the observer*. M. Pictet would say the right-eye image conceals nothing from the right eye, and the left-eye image nothing from the left eye, and therefore the parts covered by these images must be seen, by the corresponding eye, by means of illusive images; but *we* say, a part of the wall *is* concealed from the right eye (viz: that upon which the right-eye image falls), but this part is visible to the left eye; similarly, a part of the wall *is* concealed from the left eye, but this part is visible to the right. M. Pictet says, every part of the wall is

seen by *each* eye, either by true or by illusive images; we say, every part of the wall is seen, not by each eye, but by the *binocular observer;* not some parts by true and some by illusive images, but only by *true images.*

If instead of a finger we use a screen several inches wide (wider than the interocular space), then the double images will not entirely separate. They will slide over each other heteronymously through a space equal to the interocular space (2). The overlapping area will be opaque because it covers a portion of the wall concealed from both eyes; the rest will be transparent. The visual result is represented by fig. 1, in which SS is the right-eye image of the screen, S′S′ the left-eye image, and S′S the overlapping area. These facts are more completely represented by my method in figs. 2 and 3, of which fig. 2 represents the actual relation of parts, and fig. 3 the visual result. In fig. 2, R and L are the right and left eye respectively, *n* the nose.

1.



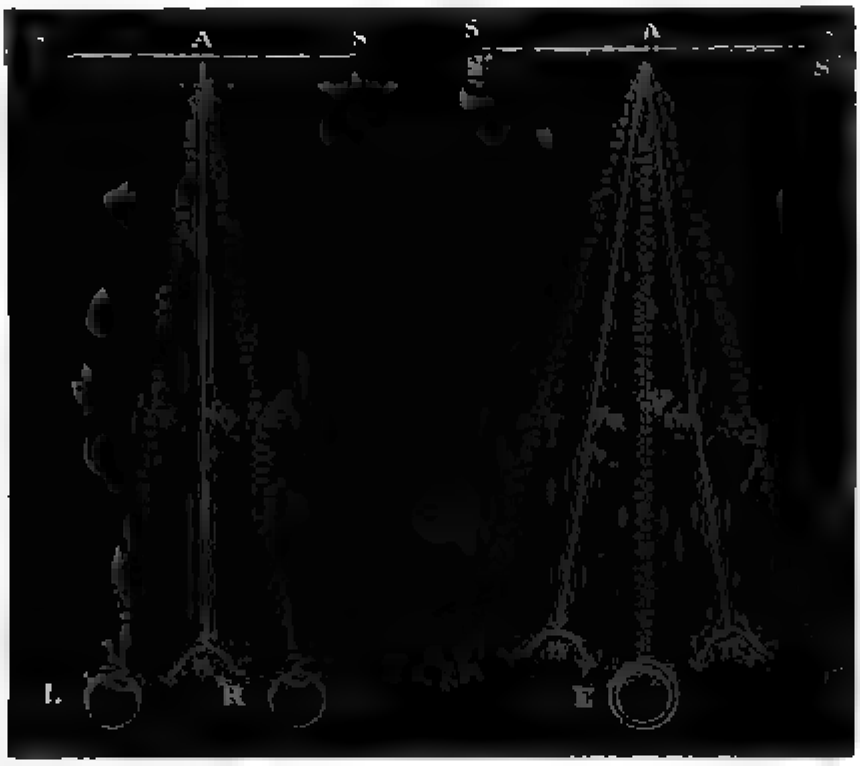
2.

3.

m the median line, *v v* the visual lines, S S the screen. Fig. 3 will readily explain itself if the reader will call to mind that in all my figures representing visual results capitals represent combined images, small italics right-eye images, and dashed italics left-eye images. If now the optic axes be gradually converged, as already explained (3), these heteronymous images will slide over each other homonymously, making the opaque area larger and larger, and the transparent margins smaller and

smaller, until when the point of sight is at the screen, fig. 4, then the images will *completely unite*, and the screen become *entirely opaque.* This is shown in the visual result, fig. 5.

4. 5.



If next we use *two* fingers, one of each hand, and gaze again at the wall, we will see four images all transparent. Now approximate or separate the two fingers until the two middle images unite; we will have three images, the middle one *opaque*, the other two transparent. The reason is obvious. The middle one is opaque because a portion of the wall is concealed by it from *both eyes.* This portion of the wall is concealed from the right eye by the right finger, and from the left eye by the left finger; but it is the right-eye image of the right finger and the left-eye image of the left finger which unite to form the middle opaque image, while the right-eye image of the left finger is seen to the left, and the left-eye image of the right finger to the right, both *transparent.* In binocular vision, *superposed images* of opaque objects are *always opaque*, while *single images* are *always transparent.*

The principles (1, 2, 3) laid down in the early part of this paper, together with the explanation of transparent double images just given, furnish, we believe, the key to all M. Pictet's experiments. We will make the application only to those which he thinks most conclusive of the existence of illusive images. We will first give his experiments and his conclusions as fairly as we can, and then will proceed to give our own explanation. The following experiments M. Pictet thinks conclusive:

Place an opaque screen S (fig. 6) against the nose *n* in the *median plane of sight*, in such wise that the object A may be

seen by both eyes. Now place a second screen C across the visual line A R of the right eye, so as to intercept rays from the object A to the right eye. Nevertheless, the object A will be seen *apparently* through the opaque screen C, which will therefore appear *transparent*, and may even be drawn in outline with accuracy on the screen at *b exactly where the visual line of the right eye pierces the screen*—exactly where, if the screen were transparent ground glass, we would see it with the right eye, and might trace its outline. M. Pictet thinks this absolutely inexplicable, except on the assumption that an illusive image is actually seen at A by the right eye; and that it is this that we draw in outline on the screen at *b*, the screen being transparent because the illusive image is seen beyond.

6.

But M. Pictet gives another experiment which he thinks still more conclusive. On a sheet of paper lying on the table place a piece of money; then place a screen upright on the right side of the money, and let the face of the observer be brought down upon the screen, so that the latter being in the median line *shall intercept the view of the right eye.* Nevertheless, says M. Pictet, "on directing the regard upon the piece of money, we see that the vertical screen appears transparent throughout, and that *it permits the right eye to distinguish the piece*, as if through a very diaphanous surface." "If now we give to the optic axes a direction more parallel, we see the image of illusion of the right eye move gradually toward the right, traverse the line of intersection of the screen and the table, and come to project itself on the other side upon the paper, where we may trace its outline correctly." To represent these facts more clearly I give the diagram, fig. 7. In this figure R and L are the two eyes, *pp* the sheet of paper, A the money in the direction of the visual line of the left eye, SS the median screen, A R the visual line of the right eye when we look at the piece of money A and seem to see it through the screen, R *b* the visual line of

7.

the right eye when the optic axes become parallel, and *b*, *exactly where the visual line of the right eye pierces the paper*, the place where the outline of the piece may be traced. The image moves to the right or left according to the position of the optic axes, being always where the visual line pierces the paper. But "the most advantageous position of the optic axes," says M. Pictet, "is parallelism, for it is that which *removes the farthest the image of illusion from the real image.*" I wonder that M. Pictet did not reflect that, being on corresponding points, by his own principle *the image of illusion*, if any, *cannot be separated from the real image;* and that *there is in fact but one image seen.*

But furthermore, if a convex lens be placed across the visual line of the right eye R *b*, the image at *b* will not be affected, but the *tracing* we make of the image will be found as much smaller than the money as the lens magnifies; showing that the image is not magnified but the drawing is magnified, and therefore, M. Pictet thinks, that the *image of the money is illusive or subjective, while the image of the paper and of the tracing is real.* If, however, the lens be placed before the *left eye*, the image is magnified because, thinks M. Pictet, this image is the *illusive right-eye fac-simile of the magnified real image of the left eye.*

One more step of M. Pictet's proof. By keeping both eyes open, objects in the microscopic field may actually be drawn with accuracy on a sheet of paper placed on one side of the microscopic tube. Or, still better, if a stereoscopic card, having a picture on one half and the other half blank, be placed in the stereoscope, we may trace the picture on the blank half. According to M. Pictet's view, the light impresses one eye, and this impression is propagated as an illusive image to the other eye, and thrown on the paper just where the visual line pierces it.

Such are the most important experiments upon which M. Pictet bases his belief in the existence of illusive images. I have been familiar with all these phenomena for many years; I have also often used the method of tracing microscopic objects recommended by him; but my explanation is wholly different. If M. Pictet's view be correct; and if in the experiments detailed we actually trace the outline of an *illusive image* belonging to the right eye, then where is the *true image* belonging to the left eye? We see but *one image.* M. Pictet, in accordance with his principles (although he forgets them in the passage quoted above), ought to answer, that being on corresponding points the two images are perfectly *united.* Then why call the image we outline an image of illusion? The truth is, in every case, we *trace the outline of the true image seen by the left eye;* although by the principles laid down in the early portion of this paper, or by the properties of corresponding points, we draw the outline at *a different place* from the object.

[To be concluded.]

ART. XL.—*On the position and height of the elevated Plateau in which the Glacier of New England, in the Glacial era, had its origin;* by JAMES D. DANA.

THE existence of a region of high elevation in northern America as the source of a continental glacier in the Glacial era has often been assumed, but rather because the glacier theory was lame without it than as a result of special research with respect to the extent and location of such a region. I do not propose, at the present time, to treat the subject continentally, but simply to discuss the question as to the origin of the New England glacier. If I mistake not, however, the discussion, so far as it goes, meets the requirements of the continental question, while it proves that the idea of one central glacier source for the continent is without foundation.

1. *Position of the elevated plateau.*—In my paper of last month, on the "Valley Movements of Glaciers," (p. 233) I mentioned the fact, from the observations of the Vermont Geological Survey, that the glacial scratches on Camel's Hump, Mt. Mansfield and Jay's Peak, three of the high summits of the Green Mountains in the northern two-thirds of Vermont, have a course of about S. 50° E.* In the White Mountains, 70 miles to the south of east (S. 75° E.), the direction of the scratches near the Lake of the Clouds, on the north side of Mt. Monroe, is, as I am informed by Prof. C. H. Hitchcock, at points from 5000 to at least 5200 feet above the sea, in different places, S. 34° E. and S. 54° E. (S. 20° E. and S. 40° by compass); on the north side of Mt. Clinton, 4430 feet high, (one of the White Mountain series of summits about 17 miles west of Mt. Washington), near top, S. 50° E.–S. 54° E.; and on the south peak of Mount Clinton, at a level of 4320 feet, S. 54° E. He observes further that boulders occur at a height of 5800 feet on the north side of Mt. Washington.†

These scratches, and others crossing the Green Mountains, could not have been made with the land of North America at its present level. Elevated land must have existed to the north, if they were the work of glaciers. Moreover, these scratches

* According to the Vermont Geological Report the direction of the scratches on Camel's Hump is S. 50° E. (S. 40° E., compass), on Jay's Peak, S. 50° E., and on Mt. Mansfield, situated between the two, S. 30° E., S. 55° E., S. 58° E., at different points.

† Prof. Hitchcock observed also the course S. 24° E. near the Lake of the Clouds, but it was not common; also, in the saddle between Mt. Pleasant and Mt. Franklin, 4400 feet above the sea level, S. 34° E.; and the same in the gap between Mt. Pleasant and Mt. Clinton, 4050 feet high. It would therefore appear that the course of the general glacier over the White Mountain region was about S. 55° E., and that there were variations from this course due to the lay of the land.

on the higher summits of New England, must point approximately toward the region of elevated land, or the great Icy Plateau, as we may call it, on whose slopes the movement of the glacier originated.

This seat of power in the era of ice was not the Adirondacks; for these stand (as will be seen on any map of North America, and even a map of the World) much too far to the south. The scratches point over Lake Champlain and the low hills and plains beyond, and across the St. Lawrence. On the other side of this river lies the large valley of the Ottawa, and it is almost exactly in their direction; and the prevailing trend of the scratches through its lower half is about S. 45° E. According to the table in Logan's Report for 1863 (p. 890), this is the course at Ottawa City, Hull, Rideau River at Stegman's Rapids, and Horton near Renfrew village south of the Ottawa. At Allumettes Lake, the course S. 25° E. was found; but this locality is higher up the stream, and the course may well have been due to some local influence. There can be no doubt that, if the Glacial era was a *glacier* era, the Ottawa valley ice was a part of the same great ice-stream with that which crossed the Green Mountains, but a portion nearer the source.

The Ottawa valley, including that of Montreal River (which has the course of the Ottawa and is its western head-tributary), extends to a point nearly 500 miles in an air-line from Mt. Mansfield, and 570 from the White Mountains, with an average trend of S. 65° E. But the source of Montreal River was not the source of the glacier movement; for the course of the scratches in the Ottawa, instead of corresponding with the trend of the valley, is, as stated, S. 45° E. The scratches point, therefore, to the eastward of the western source of the Ottawa, and at least as far east as the region northeast of Lake Temiscamang (the main source of the waters of the Ottawa), on the watershed between the St. Lawrence valley and Hudson's Bay. The scratches of the White Mountains and Green Mountains and those of the lower part of the Ottawa valley point alike toward this area.

It follows that the Icy Plateau, whence the great glacier took its departure, must have existed either about this part of the Canadian watershed, or in the same direction farther to the northwest; and since the line of the scratches, if carried farther to the northwest, would strike Hudson's Bay, or its western border, it is probable that this watershed was the actual position.

This view accords with the great diversity of direction in the scratches about Temiscamang Lake, they varying, according to Logan, from S. 78° E. to S. 7° W., the least easting being found on the *west* side of the Lake; the observations are,

at East Bay, S. 58° E., S. 78° E.; on the east shore S. 38° E., S. 18° E.; at West Bay, S. 15° E.; on the west shore, S. 35° E., S. 18° E., S. 14° E., S. 1° E., S. 7° W.

The courses of the scratches on the heights of northern Maine (S. 59° E. on Mt. Abraham, C. H. Hitchcock) also favors this conclusion. Again, in the part of Canada, north of northeastern Maine, on the Madawaska River, about Temiscouata Lake, Logan found scratches trending S. 54° E., S. 52° E., S. 55° E., S. 66° E., S. 48° E., S. 60° E., (with one of S. 27° E.); and these courses, if the form of the surface has not increased the easting, would point to the same watershed and the part lying between Temiscamang and Mistissinny Lakes, but nearer the latter, and these lines continued would strike into Hudson's Bay, and this is additional proof that the high land was along the watershed.

Again, the courses of the scratches in western New York and on Lake Huron and Lake Nipissing (northeast of Lake Huron and south of Lake Temiscamang), have considerable *westing*. On the north shore of Lake Huron the course is mostly S. 13°–22° W., according to Logan; on the Georgian Bay (northeastern side of Lake Huron), S. 37°–45° W.; at the southeast bay of Lake Nipissing, S. 35° W; in western New York, S. 35° W., according to Hall. This prevalent *westing* points toward the same region northeast of Lake Temiscamang along the Canadian watershed, and seems to shut off from consideration regions farther north or west.

Taking into view all the observations here cited, we may conclude with much confidence that the region of greatest elevation along the watershed, or that of the Icy Plateau, was situated between Lake Temiscamang and Lake Mistissinny; and that its trend was consequently northeast and southwest, this being nearly that of the watershed between the lakes—a trend just right for a southeast movement of the ice.

Over the higher parts of the Green Mountains, *south* of Vermont, the amount of easting in the scratches diminishes southward, their direction being S. 40°–45° E. in northeastern Massachusetts; about S. 30° E. in southeastern Massachusetts; and about S. 25° E. in Connecticut and in eastern New York adjoining. These directions correspond well with the position assigned to the Icy Plateau. But as the Adirondacks lie between the two, it is not possible to say how far the courses may have been dependent upon these New York mountains.

2. *Height of the Icy Plateau above the sea.*—The higher summits of the Green Mountains are, according to Guyot, between 3800 and 4430 feet in elevation, the latter being the height of Mt. Mansfield. Killington Peak, 60 miles south of Mt. Mansfield and east of Rutland, is 4221 feet high (Guyot). The average height of the range, according to the same authority, is

about 3500 feet. The distance from Mt. Mansfield to southeastern Massachusetts is about 200 miles. The scratches of this mountain point southeastward toward the upper Merrimack valley; and those of this valley and of the adjoining region, down this valley in the direction of Boston Bay; and to this bay the distance from the summit of Mt. Mansfield is but 175 miles. Still, taking 200 miles as the length of the old glacier from Mt. Mansfield to the sea, and 3500 feet as the average height of the Green Mountains in Vermont, *the average rate of descent in the land is* 17½ *feet a mile*, and 20 feet a mile from the summits of the higher peaks. This was consequently the amount of slope that contributed toward the movement of the glacier over a large part of New England.

To have moved the same glacier from the northwestward *across the Green Mountains*, and to have abraded their highest summits and also scored surfaces on the White Mountains that are full 5200 feet above the sea, the propelling slope, or those of the Icy Plateau, must have certainly been higher than 5200 feet. We cannot assume that the rate of descent from the top of the Icy Plateau to the 5200 foot level on the White Mountains, a distance of about 400 miles, was as great as seventeen feet a mile; but we may reasonably infer it to have been at least *three* feet. This rate for 400 miles would make the height of the Plateau to average 6400 feet. The watershed is now about 1500 feet above the sea; accordingly, the average height of this region should have been at least 4900 feet greater than now.

A grade of *two feet* a mile would diminish this estimate 400 feet, making the required average height of the Icy Plateau 6000 feet.

The facts, therefore, demonstrate that this Canadian watershed was greatly higher—at least 4500 feet on an average—than at present. It is not supposed, or supposable, that the region was the course of a range of crested mountains that have since been washed away. No facts connected with glacial denudation, or that of subsequent time, favors such an extravagant assumption. All that the case demands is simply a bending upward of the surface over a wide area through a general continental movement of the crust having its greatest results to the north; and such we may believe it to have been. Similar oscillations of surface upward, and again downward, have taken place through all geological time, and they are still in progress; and geologists have detected them on some sea-shores where there is a standard water-level for comparison.

Moreover, the work of lifting continents and raising mountain chains went forward on a stupendous scale over Europe, Asia, and both Americas, through the whole era of the Tertiary; and this later upward movement in the higher latitudes of the continent followed on as the close of the long series, all

the preceding elevations, as well as the last, being in preparation for the Glacial era.

Such an *upward* bending is no more improbable than the *downward* bending which the Iceberg theory of the drift assumes to have taken place; and even less so, *since* the latter must have been greater in *vertical change* of level, and also vastly wider in its limits from north to south; and moreover such an event would have been out of joint with the times, tending to ameliorate instead of giving arctic vigor to the climate. And further, as I pointed out many years since, (this Journal, II, vii, 379, 1849,) there is independent proof of a high-latitude elevation of the continent during the Glacial era, in the fact that the drift latitudes are also *fiord* latitudes,—the fiords occupying valleys of erosion by fresh water or ice, which could have been made only when the land was far above the present level.

A bulging of the crust in any region to a height of 4,500 or 5,000 feet above its present level would have carried up the part of the continent adjoining to a greater or less extent. If the above use of fiords is right, they may help us, wherever they occur, in arriving approximately at the amount of elevation in the Glacial era along sea borders. From the depth of those of Maine,—mostly 100 to 150 feet--we thus learn that the land along this coast was at least 150 feet higher than now, and probably 200 feet. Other facts lead us to believe, as stated by the writer in his paper on the Geology of the New Haven region, (Mem. Acad. Conn. ii, p. 45,) that southern New England was 100 to 150 feet above its present level. Hence, the coast line of New England would have been much extended outward by the change of level. Long Island Sound would have been reduced to a narrow channel, and Long Island joined to Connecticut, to which it geographically belongs. St. Lawrence Bay would have been greatly contracted, and the St. Lawrence River lengthened seaward over part of its present site. Lake Champlain would have poured its waters down the valley of the Hudson; and, as others have shown, Lake Michigan down the Mississippi valley.

The elevation of New England would have increased in amount from the southern shore northward, and from the southeastern northwestward, toward the Icy Plateau. Consequently the White Mountains, Mt. Mansfield and other Green Mountain peaks, and the Adirondacks of northern New York, would probably have stood at least 500 feet above their present level. If so, it is necessary, in order to have the slope of one averaging two or three feet in a mile, that as much at least should be added to the average height of the great northern Icy Plateau, which would make it 6,500 to 7,000 feet.

If the Icy Plateau, instead of being along the watershed, was situated to the north and northwest of it, somewhere in

central or northern North America, the height must have been greater in proportion to the remoteness.

3. *The movement of the Glacier.*—The great glacier moved southeastward (the Icy Plateau trending northeastward) down the valley of the Ottawa and the slopes east of it, and marked its course deeply in the subjacent rocks. But on nearing the St. Lawrence, the lower part of its mass yielded to the impulse of gravity according with the slopes of this transverse valley, so that along this valley only *southwest* scratches were made, as facts show. Yet, the upper part of its mass continued on its first course, and, in northern New York and Vermont, and over southern Canada adjoining the latter State, the southeastward moving ice again touched bottom and resumed its work of abrasion. This is precisely parallel to what happened to the glacier, as I have shown, in its passage across the Connecticut River valley. In each case the valley determined the movement along its course of an under portion of the glacier, while the upper portion, spanning the valley, continued the grander movement initiated in the Icy Plateau, and favored by the general slope of New England. The great glacier, 6,000 to 8,000 feet in thickness, had no difficulty in keeping on its course according to the general slope of the land, and, at the same time, in following underneath the larger valleys or even many of the local slopes. It could not do otherwise. Icebergs in a continental sea, on the contrary, would have been puzzled to find all the criss-cross currents needed to help them along the valleys, up hill and down, and through all points of the compass.

4. *One cause of the cold of the Glacial era in North America.*—Increase in the extent and height of high-latitude lands may well stand as one cause of the cold of the American Glacial era. This rising of the land of northern Canada into a great plateau, at least as high as the summit of Mt. Washington, with the less elevation of wide regions north and south as a part of the great swell of the surface, and with the simultaneous elevation of other, perhaps higher, plateaus over the more northern and northwestern portions of the continent, and all a sequel to the majestic uplifts of the Tertiary, would have made a *Glacial* period for North America, whatever the position of the ecliptic, or whatever the eccentricity of the earth's orbit, though more readily of course if other circumstances favored. Having the most elevated land of eastern North America along the region pointed out, the courses of the winds and the distribution of moisture would have been different from the present. Canada being then on the *seaward* slope of the high land instead of, as now, on the landward slope, could not have had its comparatively dry climate with only an annual fall of 30 inches of moisture.

5. *Epochs of the Quaternary in North America.*—In view of the facts with regard to the elevated northern lands of the Glacial era here set forth—facts if Glaciers had anything to do with the Glacial phenomena—the epochs of the Quaternary, before deduced by the writer, come out in great boldness.

The movement of the GLACIAL era carried the northern lands upward, at least 5,000 feet above their present level in northern Canada, and probably as much or more over the higher latitudes to the west and north.

Then followed a slowly progressing subsidence—the great characteristic of the CHAMPLAIN era—which ultimately sank the same lands even to a greater extent than they had been raised, placing the valley of the St. Lawrence, about Montreal, over 500 feet below its present level, and probably 1,000 feet at least below its level in the Glacial era. With the commencement of this movement, or as it progressed, began the melting of the glacier; but the era continued, as proved by elevated beaches full of shells and other deposits, long after the melting ceased. During it, owing to the larger amount of subsidence to the north, north and south rivers had their slope greatly diminished, and in some places leveled out entirely for long distances; and owing to the vast depositions of drift, rivers, like Niagara, sometimes had their channels obstructed and were forced to begin new cuts, while other water-courses of the Glacial era were wholly cut off, as that from the Champlain Lake down the Hudson valley.

Afterward the return movement, that of the TERRACE era followed, placing the land finally at its present level, leading thus to a deepening of river channels, and thereby to the making of the river and lake terraces that cover the continent.

The fact of these grander movements which mark the three eras does not preclude the possibility of minor local oscillations of level during their progress.

ART. XLI.—*Variations in the Temperature of the Human Body;* by B. F. CRAIG, M.D. (Read before the Phil. Soc. of Washington).

IT is well understood that the temperature of the human body is kept approximately uniform under very various external conditions by a system of physiological compensations, and at the same time, it is not doubted that a certain amount of warming and of chilling does take place in spite of those compensations.

In disease, we have *occasionally* depressions of the temperature below the normal standard of 98.°4 Fah., and *frequently* considerable elevations above it—a rise of 2°, 4°, or even 6°

Fah., accompanying ordinary febrile disturbances. The peculiarity attending the rise of temperature in disease is that it is not much felt by the patient himself. In mild intermittent fever and in tubercular consumption, the heat of the body will often be found 1½° or 2° above the standard of health, while no sense of unusual heat, and sometimes no bodily discomfort of any kind, is felt by the sick man. Even in the more serious fevers, where the temperature goes up to 102°, 104°, or higher, there is not always a sense of increased heat proportioned to the disturbance of temperature: and moreover, the state of the temperature is governed mainly by the severity of the disease, and not by such external circumstances as the heat of the weather and the amount of clothing.

The great and long continued heat of the summer of 1870 gave me an opportunity, which seems unlikely to recur during the present summer, of investigating on myself to what extent the temperature of the healthy body was liable to rise under the influence of oppressively warm weather.

In the course of my experiments the highest temperature that I found was that of 99°·7 Fah. At this temperature I felt quite unpleasantly overheated, but not as much so as I would have been if instead of spending the morning indoors, I had been exposed to the rays of the sun in the open air. When the temperature of my body was below 99° I never felt uncomfortably hot. In fact, I satisfied myself by repeated trials, that a temperature of 99°·2 must be reached before the sensation of suffering from heat comes on.

During the hottest weather, I was able, by the prolonged use of the shower bath, to reduce my temperature to 97°·7. If, while at or about this temperature, I went into the street in the middle of a very hot day, the greatness of the heat was plainly felt as a sensation, but not as a cause of discomfort, as a man in cool weather might feel the glow of a furnace near which he was standing without being distressed by it. In fact, until my temperature had risen to 99°, I merely *perceived* how hot it was without being troubled by it.

It would thus appear that the discomfort we feel in hot weather is not from the impression of heat on the surface, but from the secondary effect of the heating up of the whole body; or rather, it is only when the heat of the whole body has risen nearly 1° Fah. that a check of the surface cooling begins to be unpleasant.

Very great elevations of temperature have been observed in sun stroke or heat apoplexy. That in all such cases the heat of the body rises above 100° Fah. before alarming symptoms manifest themselves, I think highly probable. Accurate thermometric examinations of mild cases of sun stroke and of per-

sons supposed to be on the verge of apoplexy from excessive heat, may be pointed out as scientific desiderata.

In the Philos. Trans. for 1792 are to be found some curious experiments by Dr. James Currie, on the cooling of the human body by cold baths. He carried the reduction of temperature as low as 88° Fah., and this seemed, from the symptoms produced, to be as far as the heat of the body could be reduced with safety. It is to be hoped that some one may supplement these researches by experiments in the direction of the elevation of the animal temperature.

ART. XLII.—*Preliminary Catalogue of the bright lines in the Spectrum of the Chromosphere;* by C. A. YOUNG, Ph.D., Professor of Astronomy in Dartmouth College.

The following list contains the bright lines which have been observed by the writer in the spectrum of the chromosphere within the past four weeks. It includes, however, only those which have been seen twice at least; a number observed on one occasion (Sept. 7th) still await verification.

The spectroscope employed is the same described in the Journal of the Franklin Institute for November, 1870; but certain important modifications have since been effected in the instrument. The telescope and collimator have each a focal length of nearly 10 inches, and an aperture of $\frac{7}{8}$ of an inch. The prism-train consists of five prisms (with refracting angles of 55°) and two half-prisms. The light is sent twice through the whole series by means of a prism of total reflection at the end of the train, so that the dispersive power is that of twelve prisms. The instrument distinctly divides the strong iron line at 1961 of Kirchhoff's scale, and separates B (not b) into its three components. Of course it easily shows everything that appears on the spectrum maps of Kirchhoff and Angstrom. The adjustment for "the position of minimum deviation" is automatic; i. e., the different portions of the spectrum are brought to the center of the field of view by a movement which at the same time also adjusts the prisms.

The telescope to which the spectroscope is attached is the new Equatoreal recently mounted in the observatory of the College by Alvan Clark & Sons.

It is a very perfect specimen of the admirable optical workmanship of this celebrated firm, and has an aperture of $9\frac{4}{10}$ inches, with a focal length of 12 feet.

In the table the first column contains simply the reference number. An asterisk denotes that the line affected by it has no well marked corresponding dark line in the ordinary solar spectrum.

Preliminary Catalogue of Chromospheric Lines.

Ref. No.	Kirchhoff.	Angstrom.	Rel. Frequency	Rel. Brightness.	Chemical Element.	Previous Observer.
	634·5	7060·7	60	3		
	654·5	6677 ?	8	4		L.
	C	6561·8	100	100	H.	L. J.
	719·0	6495·7	2	[illegible]	Ba.	
	734·0	6454·5	2	3		
	743 ?	6431·	2	2		
	768·7	6370·	2	2		
	816 8	6260·3	1	1	Ti.	
	820·0	6253·2	1	2	Fe.	
	874·2	6140·5	6	8	Ba.	L.
	D_1	5894·8	10	10	Na.	L.
	D_2	5889·0	10	10	Na.	L.
	1017·0	5871·	100	75		L. J.
	1274·3	5534 0	6	8	Ba.	R. L.
	1281 5	5526 0	1	1	Fe.	
	1343·5	5454·5	1	2	Fe.	
	1361·3	5445·9	1	[illegible]	Fe. Ti.	
	1363·1	5433·0	1	1	Fe.	
	1366·0	5430·0	2	3		
	1372·0	5424·5	3	4	[illegible]	L.
	1378·5?	5418·0?	1	2	Ti.?	
	1382 5	5412·	1	1		
	1391·2	5403·0	2	[illegible]	Fe, Ti.	
	1397·8	5396·2	1	2	Fe.	
	1421·5	5370·4	1	2	Fe.	R.
	1431·3	5360·6	2	2		R. ?
	1454·7	5332·0	2	2	Ti.	
	1462·9	5327·7	1	3	Fe.	
	1463·4	5327 2	1	3	Fe.	
	1466·0?	5321·	2	2		
	Cor'na line 1474 1	5315·9	75	15	Fe?	L.
	1505·5	5283·	5	4		
	1515·5	5275 0	7	5		L. R.
	E_1	5269 5	1	3	Fe, Ca.	
	E_2	5268 5	1	2	Fe.	
	1526·0	[illegible]	3	2	Fe. Co.	L.
	1561·0	5239·0	1	1	Fe.	
	1564 1	5236·2	1	1		
	1567·7	5233·5	2	2	Mn.	R.
	1569·7	5232·0	1	2	Fe.	
	1577 3	5226·0	1	2	Fe.	
	1580·5?	5224·5	1	1	Ti.	
	1601·5	5207·3	3	3	Cr, Fe.?	
	1604 4	5205·3	3	3	Cr.	
	1606.5	5203·7	3	3	Cr, Fe.?	
	1609·3	5201·6	1	2	Fe.	
	1611·5	5199·5	1	1		
	1615·6	5197 0	3	2		L. R.
	b_1	5183·0	15	15	Mg.	L.
	b_2	5172·0	15	15	Mg.	L.
	b_3	5168·5	12	10	Ni.	L.
	b_4	5166.5	10	10	Mg.	L.
	1673 9	5163·2	1	1	Na.	
54	1678·0	5150·1	1	2	Fe.	
55	1778·5	5077·8	1	1	Fe.	
56	1866·8	5017·5	2	3		R.
57	1870 3	5015·7	2	2		R.
58	1989·5	4933·4	8	5	Ba.	L.
59	2001·5	4923·2	5	3	Fe.	R. L.
60	2003·2	4921·3	1	1		
61	2007·1	4918·1	3	3		L.
62	2031·0	4899.3	6	4	Ba.	L.
63	2051·5	4882·5	2	2		L.
64	F.	4860·6	100	75	H.	J. L.
65	2358·5	4629·0	1	1	Ti.	
66	2419·3	4583·5	1	1		
67	2435·5	4571·4	1	1	Li.	
68	2444·0	4564 6	1	1		
69	2446·6	4563·1	1	2	Ti.	
70	2457·8	4555·0	1	1	Ti.	
71	2461 2	4553·3	3	3	[illegible]	
72	2467·7	4548 7	1	3	Ti.	
73	2486·8	4535·2	1	1	Ti. Ca. ?	
74	2489·5	4533·2	1	1	Fe.	
75	2490·6	4531 7	1	1	Ti.	
76	2502 5	4524·2	2	2	Ba.	
77	2505·8	4522·1	1	2	Ti.	
78	2537·3	4500·4	1	3	Ti.	
79	2553·?	4491·0?	1	1	Mn. ?	
80	2555·?	4489·5?	1	1	Mn. ?	
81	2566·5	4480 4	1	2	Mg.	L.
82	2581·5?	4471·4	75	8	A band rather than a line.	
83	2585·5	4466·6	1	1	Ti.	
84	2625·0	4443·0	1	1	Ti.	
85	2670·0	4414·6	1	1	Fe, Mn.	
86	2686·7	4404·3	1	2	Fe.	
87	2705·0	4393·5	3	2	Ti.	
88	2719·?	4384·8	1	1	Ca. ?	
89	2721·2	4382·7	1	2	Fe.	
90	2734·?	4372·	1	1		
91	2737·?	4369·3?	1	1	Cr. ?	
92	2775·8	4352·0	1	1	Fe. Cr.	
93	2796·0	4340·0	100	50	[illegible]	L. J.
94	G.	4307·0	1	2	Fe. Ti. Ca.	
95	2770·0	4300·0	1	1	Ti.	
96		4297·5	1	1	Ti, Ca.	
97		4289·0	1	2	Cr.	
98		4274·5	1	2	Cr.	
99		4260·0	1	1	Fe.	
100		4246·2	1	1	Fe.	
101		[illegible]	1	1	Ca.	
102		4216·5	1	2	Fe. Ca.	
103	h.	4101·2	100	20	H.	R. L.

The second column gives the position of the line upon the scale of Kirchhoff's map—determined by direct comparison with the map at the time of observation. In some cases an interrogation mark is appended, which signifies not that the *existence* of the line is doubtful, but only that its precise place could not be determined, either because it fell in a shading of fine lines, or because it could not be decided in the case of some close double lines which of the two components was the bright one; or finally because there were no well marked dark lines near enough to furnish the basis of reference for a perfectly accurate determination.

The third column gives the position of the line upon Angstrom's normal atlas of the solar spectrum. In this column an occasional interrogation mark denotes that there is some doubt as to the precise point of Angstrom's scale corresponding to Kirchhoff's. There is considerable difference between the two maps, owing to the omission of many faint lines by Angstrom, and the want of the fine gradations of shading observed by Kirchhoff, which renders the coördination of the two scales sometimes difficult, and makes the atlas of Kirchhoff far superior to the other for use in the observatory.

The numbers in the fourth column are intended to denote the percentage of frequency with which the corresponding lines are visible in my instrument. They are to be regarded as only roughly approximative; it would of course require a much longer period of observation to furnish results of this kind worthy of much confidence.

In the fifth column the numbers denote the relative brilliance of the lines on a scale where 100 is the brightest and 1 the faintest. These numbers also, like those in the preceding column, are entitled to very little weight.

The sixth column contains the symbols of the chemical substances to which, according to the maps above referred to, the lines owe their origin.

There are no disagreements between the two authorities; in a majority of cases, however, Angstrom alone indicates the element, and there are several instances where the lines of more than one substance coincide with each other and with a line of the solar spectrum so closely as to make it impossible to decide between them.

In the seventh and last column the letters J., L. and R. denote that to my knowledge the line indicated has been observed and its place published by Janssen, Lockyer or Rayet. It is altogether probable that a large portion of the other lines contained in the catalogue have before this been seen and located by one or the other of these keen and active observers, but if so I have as yet seen no account of such determinations.

I would call especial attention to the lines numbered 1 and 82 in the catalogue: they are very persistently present, though faint, and can be distinctly seen in the spectroscope to belong to the chromosphere as such, not being due, like most of the other lines, to the exceptional elevation of matter to heights where it does not properly belong. It would seem very probable that both these lines are due to the same substance which causes the D^3 line.

I do not know that the presence of *Titanium vapor* in the prominences and chromosphere has before been ascertained. It comes out very clearly from the catalogue, as no less than 20 of the whole 103 lines are due to this metal.

Hanover, N. H., Sept. 13, 1871.

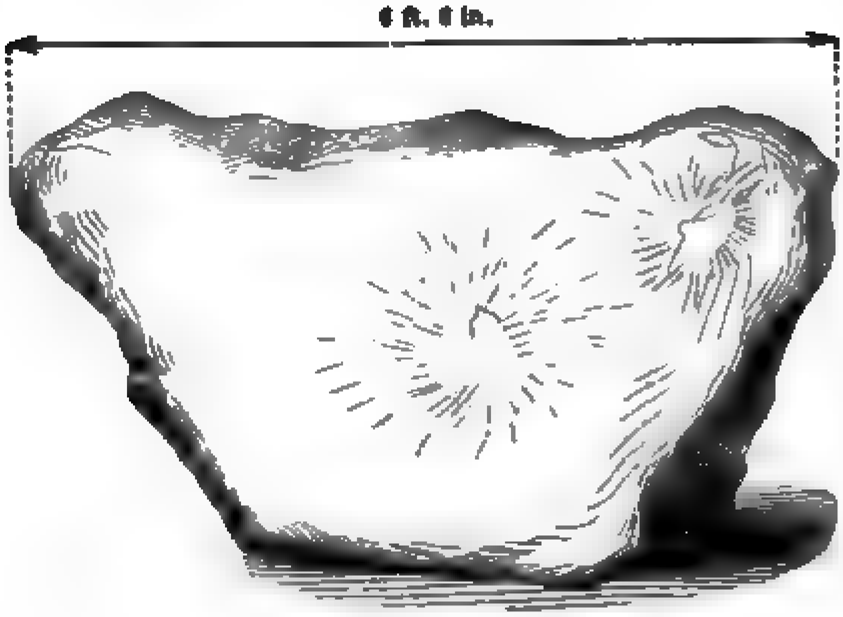
ART. XLIII.—*The precise Geographical position of the large masses of meteoric iron in North Mexico, with the description of a new mass—The San-Gregorio Meteorite;* by J. LAWRENCE SMITH, Louisville, Ky.

SOME of the remarkable masses of meteoric iron in Northern Mexico have been known to travelers for a number of years; but no very precise information concerning them had been given until the year 1854, when the first mass, brought from that locality, was placed at my disposal by Lieut. Gouch of the U. S. Army, and was described in a memoir on meteorites published in the American Journal of Science, April, 1854; it is now in the Smithsonian Museum, and weighs 252 lbs.

On the return of Mr. Bartlett, of the Boundary Commission, I learned of two other masses in that region, and Lieut. John G. Parke, of the U. S. Army, placed a fragment of one of them in my possession; the fragment of the other mass was lost. I figured and described both of those meteorites in the memoir just alluded to; the first, which I called the *Tucson Meteorite*, is now in the Smithsonian Institute, and weighs, I believe, several thousand pounds; the second one I called the *Chihuahua iron*, and is still at the *Hacienda de Conception*, where it was first found. Still later in the year 1868, Dr. H. B. Butcher placed under my examination eight masses of meteoric iron that had been brought to the United States from the same region of Mexico; these I examined, and published a full account of in the American Journal of Science. These masses are now in Philadelphia, still owned by Dr. Butcher, and vary in weight from about 300 lbs. to 800 lbs. Dr. Butcher having returned to Mexico, I requested him to get all possible information in regard to the geographical position of these bodies; this he

has succeeded in accomplishing. At the same time he has a fragment of another mass, still larger than any yet known, which will be called the *San-Gregorio Meteoric Iron.* Its description is as follows:

The San-Gregorio Meteorite.—This immense mass of meteoric iron is situated on the western border of the Mexican Desert, a map of which is given on the next page. Some idea of its form may be had in the accompanying sketch.



It measures 6 feet 6 inches in its greatest length, is 5 feet 6 inches high, and 4 feet thick at its base; on one part of its surface, 1821 is cut with a chisel, and above this date is the following inscription: "*Solo dios con un poder este fierro destruerá, por que en el mondo no habra quien lo puedo deschacer.*"

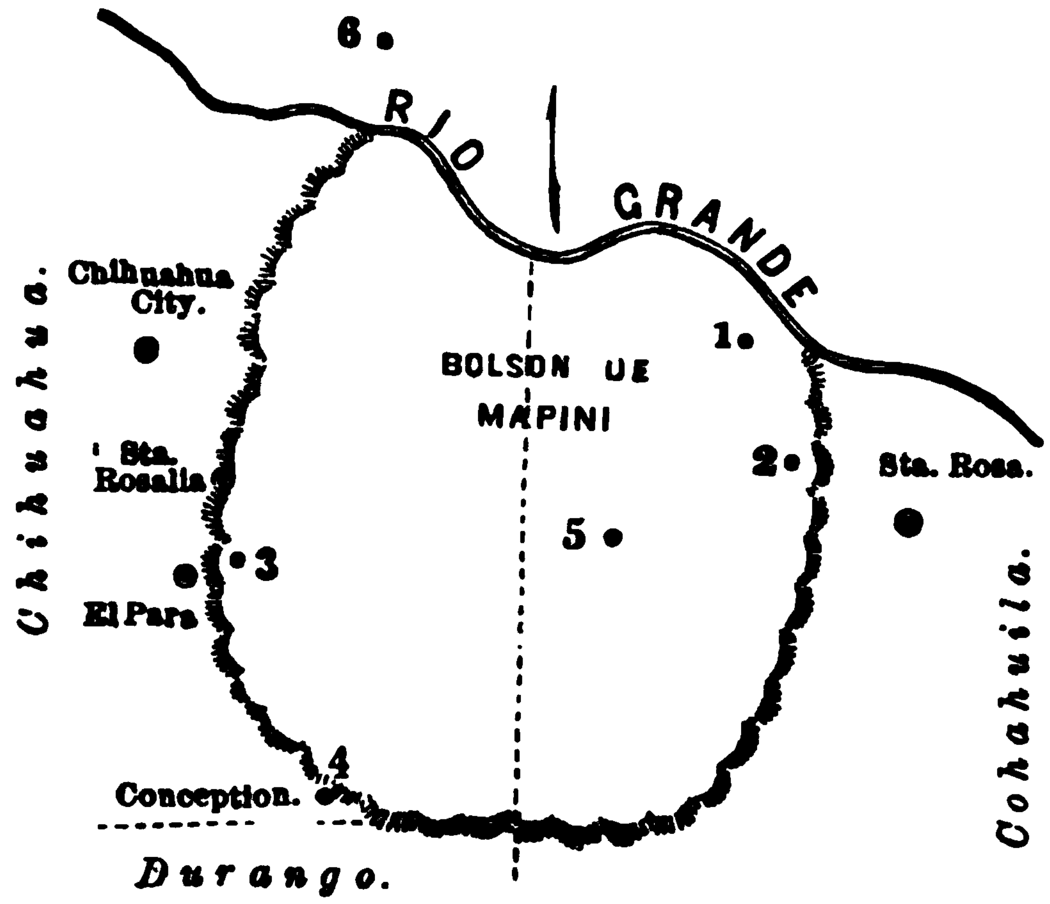
It lies within the enclosure of a hacienda, having been hauled to the ranch many years ago by the Spaniards, who thought that it could be made use of as iron for farming utensils. It is said to have fallen quite near its present site, and from its huge bulk and weight, which is calculated to be about five tons, it could not have been transported very far. Nothing more is known of its history. Small specimens were detached by Dr. Butcher, one of which I have examined. I find it to be of the softer meteoric irons, with a specific gravity of 7·84. The fragment I possess is too small for the study of the true character of its Widmannstätian figures.

On analysis, it furnished the following composition:

Iron,	95·01
Nickel,	4·22
Cobalt,	·51
Copper,	minute trace
Phosphorus,	0·08

This *San-Gregorio* iron makes the fifth that has come under my observation and examination from this famous Mexican locality, the geography of which I will now describe, referring to the accompanying diagram for details.

The Bolson de Mapini or Mexican Desert occupies the western portion of the province of Cohahuila, and the eastern portion of the province of Chihuahua. It is 400 miles from east to west, and 500 miles from north to south, bounded on the north by the river Rio Grande. Some of the villages and haciendas are specified in the diagram, and the numbers 1, 2, 3, &c., are the localities of the different meteoric masses discovered.



No. 1. The locality of the *Cohahuila* meteorite described by me in this Journal, April, 1854; it is now in the Smithsonian Institution.

No. 2. The locality of the *Cohahuila* meteorite of 1868, described by me in this Journal, April, 1870; it is now in the possession of Dr. Butcher.

No. 3. The locality of the *San-Gregorio* meteorite just described; it is still in the place where it was first observed.

No. 4. The locality of the mass described and figured in my memoir on meteorites (this Journal, April, 1854), and called the *Chihuahua Meteorite;* it is still in place at the *Hacienda de Conception*, 10 miles from Zapata, its greatest height being forty-six inches, breadth thirty-seven, and in the thickest part eight feet three inches in circumference. Signor Urquida calculated its weight to be about four thousand pounds.

No. 5. The locality of a huge meteorite lately discovered, of which no specimen has yet been detached, and is said to be larger than any one yet found in that locality.

No. 6. The locality of the large mass described and figured by me in 1854 as the *Tucson iron*, and now in the Smithsonian Institution at Washington, having a large hole in the center, and

sometimes called the *Signet Meteorite*, also the *Ainsa Meteorite*. I do not know its exact weight, but suppose that it must weigh two or three thousand pounds.

The question naturally arises, what can be the cause of the number of meteoric masses in the circumscribed region, and whether each one represents a separate fall? My study of them leads me to the belief that they are the products of two falls. First of all, No. 6, the Signet or Ainsa meteorite, has peculiar physical and chemical characters that separate it entirely from the others. Nos. 1, 2 and 3 I have examined chemically, and find them very closely allied in composition, also in physical properties, as the softness of the iron and freedom from rusty crusts over the exterior; in fact the pieces I have examined were more or less bright on the exterior surface. The Widmannstätien figures I have not had an opportunity to compare, since, with the exception of No. 1, I have had only small pieces that were detached from the surface by a cold chisel, which are unfit for the study of these figures. Thus far in my investigation, there appears strong reasons for supposing that at some epoch, probably far remote, the meteoric masses 1, 2, 3, 4 and 5 were the products of the fall of one meteoric mass, moving from the northeast to the southwest, the smaller masses falling first at 1 and 2, and the larger masses farther on. The distances of these bodies from each other are, from Nos. 1 to 2 about 85 miles, from 2 to 5 about 135 miles, from 5 to 3 about 165 miles, from 3 to 4 about 90 miles. Of course these is no great stress laid upon these deductions, but it would not be surprising if further investigation should sustain this view.

Since my first publication on these meteorites, Burckhardt, of Bonn, has made some observations upon them, but his publications are not within my reach at the present time.

ART. XLIV.—*On the Iridium compounds analagous to the Ethylen and Protochloride of Platinum Salts;** by Prof. SAMUEL P. SADTLER, Ph.D., Pennsylvania College, Gettysburg, Pa.

AMONG the compounds which we are accustomed to call *organo-metallic*, those of $PtCl_4$ and $PtCl_2$ play perhaps the most important part. We can separate them, however, into the two great classes—those where the $PtCl_4$ and $PtCl_2$ enter by substitution into compound ammonia-atoms, and thus form bases more or less complex, but having still a certain connection: and those where the $PtCl_4$ and $PtCl_2$ take up organic radicals of different degrees of valence to form saturated compounds.

* Extract from an Inaugural dissertation at the Univ. of Göttingen, April, 1871.

The range of this last class, as can be seen, is very wide; one of the most prominent of these compounds, however, and one which exercised for some time a very considerable influence upon the theoretical views held at that time, is the compound of $PtCl_2$, known as Zeise's salt, and discovered and investigated by him in 1830.

It is not necessary to recount here the controversy which took place between Zeise and Liebig on the subject. Suffice it to say that, by subsequent investigations of Griess and Martius and of Birnbaum, its formula is definitely settled as $PtCl_4$, C_2H_4+KCl.

The investigation I now undertook was to see if a similar base of iridium could be prepared. Various considerations, stated at length in my original paper, led me to believe that iridium might not combine exactly as platinum did, in the formation of these salts.

After obtaining the double chloride of iridium and ammonium in the usual way, by decomposing the osmiridium, I made some tests as to the manner of formation of the salt. An attempt to form it by taking the double chloride of iridium and ammonium in solution, and, passing a stream of chlorine through to break up the chloride of ammonium, to then conduct ethylen gas into it, was unsuccessful. The method which succeeded most perfectly was to act upon iridium chloride. This was obtained by igniting the double chloride of iridium and ammonium, thus obtaining iridium oxide and metallic iridium, which was then heated with aqua regia in sealed tubes of bohemian glass to 180° or 200°C. This solution of $IrCl_4$, I then treated with absolute alcohol. On adding KCl, and allowing it to crystallize out, I got the greenish-brown crystals of the iridium-ethylen base. On subjecting them to an organic combustion, I obtained as products carbonic acid and water. They burned with a luminous flame, and answered, in short, all the tests applied to Zeise's platinum salt.

Another experiment, to see if ethylen gas would act directly upon the $IrCl_4$, reducing it and uniting at the same time, was unsuccessful.

It will thus be seen, that the only method of preparing the iridium-base is by the reducing action of alcohol on iridium chloride, according to the reaction:—

$$\underbrace{IrCl_2}\ \underbrace{Cl_2 + \begin{matrix} CH_3 \\ | \\ CH_2OH \end{matrix}} + \left|\begin{matrix} CH_2 \\ | \\ CH_2 \end{matrix}\right|\begin{matrix} H \\ \\ OH \end{matrix} = IrCl_2,\ C_2H_4 + 2HCl + \begin{matrix} CH_3 \\ | \\ COH \end{matrix} + H_2O$$

the products of which are iridium-ethylen-protochloride, hydrochloric acid, aldehyde and water.

The purifying of the necessary iridium was found to be a very long and tedious operation, the last traces of platinum

sticking very pertinaciously to the iridium salt. The processes in use also leave much to be desired in the way of completeness and expedition.

The method selected for separation was the method of Birnbaum, grounded upon the distinct and separate crystallization of the double cyanides of iridium and barium and platinum and barium. To convert the double chlorides of iridium and ammonium, and platinum and ammonium into the double cyanides of iridium and potassium, and platinum and potassium, after trying Wöhler's and Muckle's method and obtaining unsatisfactory results, I had recourse to Martius' method. This consists in mixing the dry impure chloride of iridium and ammonium with powdered cyanide of potassium, and fusing and then taking up with water the fused mass. After working some time with this method, with rather poor results, owing to the high heat required to bring the mass to fusion and the invariable decomposition of the newly formed double cyanides, resulting from the application of such a heat, I modified the method in several particulars. I found, on trying, that the black iridium oxide went very readily into solution in the fused cyanide of potassium. Taking, therefore, the double chloride of iridium and ammonium and igniting it to transform it into the iridium oxide, I proceeded after the following manner. Covering the bottom of the crucible with a bed of powdered KCy, I then added a mixture of KCy and iridium oxide, and exposed it to the flame of the blast-lamp. The fusing cyanide takes up quite readily the metallic oxide, and is soon in calm fusion. A reduction still takes place, but by no means to the extent experienced before. This is occasioned by the strong heat which has to be applied to get the mass into full fusion. Another modification which I then made has some advantages over this just described. It is to bring a few pieces of KCy to full fusion, and then keeping it so, to add a previously prepared mixture of the iridium oxide and finely pulverized cyanide of potassium to it, in small quantities at a time. The advantage here is, that, when the KCy has once been brought to fusion, it can be kept there with a comparatively small flame, and the reduction of the double cyanides does not occur so readily. It is true, that adding the iridium so slowly, the compound is kept in the fused state longer. My experience, however, leads me to prefer this latter plan, and I generally used it as giving the largest yield. Birnbaum's method proper is now used. The solution of the double cyanides, filtered off from any unattacked iridium oxide, contains a tolerably large excess of free KCy. This is destroyed by adding dilute HCl. When neutral, a concentrated solution of copper vitriol is added. The violet-colored precipitate of mixed double cyanides of iridium and platinum with copper is

washed by decantation with boiling water. While suspended therein, a strong solution of caustic baryta is added. The copper is thrown down as brown oxide of copper, and the double cyanides of iridium and platinum with barium are formed, which remain in solution. When the fluid reacts distinctly alkaline, after a minute or so boiling, it is filtered off, and then CO_2 is passed through, until a neutral reaction is obtained. Filter off the precipitate of $BaCO_3$, and then concentrate for crystallization. The yellow platinum salt crystallizes out first in small crystals, with a play of colors from yellow to blue, being similar in their dichroic effects to most of the other double cyanides of platinum. The iridium salt crystallizes then in larger colorless prisms, which can be easily separated mechanically from the platinum crystals. The iridium crystals I ignited in a porcelain crucible, and having thus completely broken up the compound, drew out the baryta with boiling water. The iridium, after being well washed and ignited to completely oxidize it, was heated as before with aqua regia in a sealed tube to 200°C. The $IrCl_4$ solution obtained was again treated with absolute alcohol, and, on addition of KCl and NH_4Cl, the crystallized salts were obtained.

However the compounds which were now formed were, contrary to my expectations, not the ethylen salts pure and alone, but there was a simultaneous formation of what appear to be several distinct compounds. Although in one preparation of ammonium salt analyzed, the ethylen-protochloride-salt was isolated tolerably pure, yet, in the majority of the analyses, I had to do with a mixture difficult to separate even under the lens. The readiness with which these compounds decompose when subjected to recrystallization, even although one observes the precaution of keeping the solution distinctly acid, prevents any successful purifying that way. The preparation, therefore, had to be prepared for analysis by drying between bibulous paper, and then over H_2SO_4 or at 100°, according as I wished to determine the percentage of water or not. A certain amount of HCl from the acid solutions therefore, adhering to the crystals, made the Cl determinations as a rule high. Still the results approximate sufficiently, these circumstances being taken into consideration, to the formulas given, to show that several distinct compounds are here formed. My first crystallization con sisted of brownish-red octahedra, which when analyzed gave in three Cl determinations 42·13 pr. ct., 42·07 pr. ct. and 42·09 pr. ct. Cl, showing them to be simple $IrCl_4(KCl)_2$, of which the percentage of Cl is 42·08 pr. ct.

I next got a crystallization of fine, sharply-formed monoclinic crystals of a reddish-brown color, which I think the analyses, although not perfectly conclusive, still go to show to be a new

compound. Several different crystallizations of it were analysed. It could not always be entirely separated from the slight crust of decomposed KCl which separated out along with and among the crystals.

Preparation No 1. Large well-formed crystals, with but very little foreign matter adhering to the sides.

·1567 grms. dried over H_2SO_4 lost by heating to 100° ·0170 grms. = 10·85 pr. ct.:
gave ·0525 grms. metallic iridium = 33·50 pr. ct.:
gave also ·2275 grms. AgCl = ·0563 grms. Cl = 35·92 pr. ct.

·1610 grms. dried over H_2SO_4 lost by heating to 100° ·0172 grms. = 10·68 pr. ct.:
gave — Ir. determination accidentally spoiled:
gave also ·2320 grms. AgCl = ·0574 grms. Cl = 35·65 pr. ct.

This we see at once cannot be any chloride of iridium and potassium. Its luminous flame, too, when burned, shows the same. Nor do the percentages agree with the simple potassic-ethylen iridium protochloride $IrCl_2C_2H_4KCl+2H_2O$ where the Ir. = 48·45 pr. ct. and Cl = 26·19 pr. ct.

If we reckon out the ratio of iridium to chlorine, we find it as 1 : 6, showing it to be an iridium-chloride compound. The large pr. ct. of loss on heating, the small Ir. and Cl pr. cts., when compared with double iridium and potassic chloride, and the luminous flame when burned, all go to show that an organic constituent must make the additional pr. ct. If we suppose now ethylen to enter here into the union with iridium chloride, hanging itself on, we can expect from the consideration of analogous compounds that 2 atoms of the bivalent radical C_2H_4 would join the atom $PtCl_4$.

We would have on this supposition the formula $IrCl_4(C_2H_4)_2(KCl)_2 + \chi H_2O$. Now this formula with 3 atoms H_2O gives Ir. = 32·93 pr. ct., Cl = 35·61 pr. ct., and with 2 atoms H_2O, Ir. = 33·95 pr. ct., Cl = 36.71 pr. ct.; anhydrous it gives Ir. = 36·20 pr. ct. and Cl = 39·14 pr. ct.

The large pr. ct. of loss at 100° is not accounted for by $3H_2O$, which give only 9·03 pr. ct.; but it is possible that in a compound where the organic constituent is so loosely connected with the rest, as must be the case here, a partial decomposition of the salt enters at 100° already.

In another preparation, also well crystallized, ·1822 grms. dried at 100°:
gave ·0678 grms. metallic iridium = 37·21 pr. ct.;
gave also ·3063 grms. AgCl = ·0758 grms. Cl = 41·59 pr. ct.

In another preparation, indistinctly crystallized, ·0502 grms. dried at 100°:
gave ·0172 grms. metallic iridium = 34·26 pr. ct.
(Probably low from HCl mechanically admixed.)

In another preparation, also indistinctly crystallized, ·3207 grms. dried at 100° :

gave ·2125 grms. AgCl = ·1268 grms. Cl = 39·53 pr. ct.

It will thus be seen the determinations, all things considered, agree close enough with the theoretical pr. cts. of the formula to make it very probable. The want of enough sufficiently-well crystallized material prevented me from making an organic combustion which might settle it definitely.

Several individual crystals of the first crystallization were very sharply and clearly formed, and I subjected them to examination under the microscope with a power of about 50 diameters. The faces were clearly to be made out. They belong to the monoclinic system, and their prevailing habitus in crystallization is a combination of the two lateral pinacoids with positive and negative pyramids accompanied by one macrodome on the ends. The faces observed in an examination of five distinct crystals were (according to Naumann) $\infty P \infty$. $\infty P \grave{\infty}$ $+P$. $-P$. $+\frac{1}{2}P$. $-\frac{1}{2}P$. $+P\infty$. $-P\infty$.

In considering the compounds of the iridium-base with NH_4Cl, we find again a mixture of crystallized salts.

Preparation No. 1 consisted of sharply crystallized needles that looked almost black, and only by transmitted light showed a brownish-green color. They were also monoclinic.

On analysis they prove, I think, to be the sought-for ethylen-iridium compound.

·0713 grms. dried over H_2SO_4 lost on heating to 100° ·0029 = 4·07 pr. ct.:

gave ·0850 grms. AgCl = ·0210 grms. Cl = 29·49 pr. ct. or 30·74 pr. ct. of salt dried at 100°.

The iridium determination was made with magnesium, and was inaccurate as before.

The formula $IrCl_2C_2H_4NH_4Cl + H_2O$ = 367·5 demands Cl = 28·98 pr. ct., H_2O = 4·89, or anhydrous 30·47 pr. ct. Cl.

Preparation No 2 was of much smaller needles and of lighter color.

Analyses show it to be of very similar composition to the potassium salt described above.

·1207 grms. dried at 100° C.:

gave ·0495 grms. metallic Ir. = 41·97 pr. ct.:

gave also ·2068 grms. AgCl = ·0512 grms. Cl = 43·37 pr. ct.

$IrCl_4(C_2H_4)_2(NH_4Cl)_2$ = ·502 gives Ir. = 39·25 pr. ct. and Cl = 42·43 pr. ct., and supposing it to lose some of the C_2H_4 at 100°, as stated above, $IrCl_4(C_2H_4)(NH_4Cl)_2$ would give Ir. = 41·50 pr. ct. and Cl = 44·94 pr. ct.

The other two preparations of the ammonium salt analysed appeared under the lens to be mixtures of the iridium proto-

chloride-ethylen salt and the iridium chloride-ethylen salt given above.

The results were—

·1322 grms. dried at 100°:

gave ·0609 grms. metallic iridium = 46·07 pr. ct.

·1715 grms. dried at 100°:

gave ·0784 grms. metallic iridium = 46·95 pr. ct.

$IrCl_2 (C_2H_4)(NH_4Cl) + H_2O$ gives Ir. = 53·61 pr. ct.

$IrCl_4 (Cl_2H_4)_2 (NH_4Cl)_2$ gives Ir. = 39·25 pr. ct.

The existence of the base $IrCl_4 (C_2H_4)_2$,

I hope to settle definitely by renewed analyses of larger quantities.

While engaged with the preparation of the ethylen and iridium compound, the thought of the possibility of acetylen (C_2H_2) uniting with $PtCl_2$ or $IrCl_2$ led me to make some experiments in that direction. After a number of endeavors to form a platinum salt and analyses of the products (a detailed account of which is given in the original paper), I obtained negative results only. The existence of such a salt is highly improbable.

ART. XLV.—*Directions for Constructing Lightning-Rods.* From Essays on Meteorology; by Prof. JOSEPH HENRY.*

1st. The rod should consist of round iron, of not less than three-fourths of an inch in diameter. A larger size is preferable to a smaller one. (Ordinary gas pipe may be employed). Iron is preferred, because it can be readily procured, is cheap, a sufficiently good conductor, and, when of the size mentioned, cannot be melted by a discharge from the clouds. Other forms of rod, such as flat or twisted, will conduct the lightning, and in most cases answer sufficiently well. They tend, however, to give off lateral sparks from the sharp edges at the moment of the passage of the electricity through them, which might, in some cases, set fire to very combustible materials.

2d. It should be, through its whole length, in perfect metallic continuity; as many pieces should be joined together by welding as practicable, and, when other joinings are unavoidable, they should be made by screwing the parts firmly together by a coupling ferule, care being taken to make the upper connection of the latter with the rod water-tight by cement, solder, or paint.

3d. To secure it from rust, the rod should be covered with a coating of black paint.

* Smithsonian Miscellaneous Collections.

4th. It should be terminated above with a single point, the cone of which should not be too acute, and to preserve it from the weather, as well as to prevent its being melted, should be encased with platinum, formed by soldering a plate of this metal, not less than a twentieth of an inch in thickness, into the form of a hollow cone. Points of this kind can be purchased of almost any mathematical instrument maker. Usually the cone of platinum, for convenience, is first attached to a brass socket, which is secured on the top of the rod, and to this plan there is no objection. The platinum casing, however, is frequently made so thin, and the cone so slender, in order to save metal, that the point is melted by a powerful discharge.

5th. The shorter and more direct the rod is in its course to the earth the better. Acute angles, made by bending the rod, and projecting points along its course, should be avoided.

6th. It should be fastened to the house by iron eyes, and may be insulated by cylinders of glass. We do not think the latter, however, of much importance, since they soon become wet by water, and, in case of a heavy discharge, are burst asunder.

7th. The rod should be connected with the earth in the most perfect manner possible; and in cities nothing is better for this purpose than to unite it in good metallic contact with the gas-mains or large water-pipes in the streets; and, indeed, such a connection is absolutely necessary, if gas or water-pipes are within the house. Electricity, by what is called induction, acts at a distance on the perpendicular gas-pipes within a house, rendering them so highly negative, the cloud being positive, as to attract the electricity from a lightning-rod imperfectly connected with the earth, or even from the air through the roof. Damage to buildings on this account is of constant occurrence. The above connection can be made by soldering to the end of the rod a strip of copper, which, after being wrapped several times around the pipe, is permanently attached to it. Where a connection with the ground cannot be formed in the way mentioned, the rod should terminate, if possible, in a well, always containing water; and, where this arrangement is not practicable, it should terminate in a plate of iron or some other metal buried in the moist ground. It should, before it descends to the earth, be bent, so as to pass off nearly at right angles to the side of the house, and be buried in a trench, surrounded with powdered charcoal.

8th. The rod should be placed, in preference, on the west side of the house, in this latitude, and especially on the chimney from which a current of heated air ascends during the summer season.

9th. In case of a small house, a single rod may suffice, provided its point be sufficiently high above the roof; the rule

being observed, that its elevation should be at least half of the distance to which its protection is expected to extend. It is safer, however, particularly in modern houses, in which a large amount of iron enters into the construction, to make the distance between two rods less than this rule would indicate, rather than more. Indeed, we see no objection to an indefinite multiplication of rods to a house, provided they are all properly connected with the ground and with each other. A building entirely inclosed, as it were, in a case of iron rods so connected with the earth, would be safe from the direct action of the lightning.

10th. When a house is covered by a metallic roof, the latter should be united, in good metallic connection, with the lightning rods; and in this case the perpendicular pipes conveying the water from the gutters at the eaves may be made to act the part of rods, by soldering strips of copper to the metal roof and pipes above, and connecting them with the earth by plates of metal united by similar strips of copper to their lower ends: or, better, with the gas or water-pipes of the city. In this case, however, the chimneys would be unprotected, and copper lightning-rods, soldered to the roof and rising a few feet above the chimneys, would suffice to receive the discharge. We say soldered to the roof, because, if the contact was not very perfect, a greater intensity of action would take place at this point, and the metal might be burnt through by the discharge, particularly if it were thin.

11th. As a general rule, large masses of metal within the building, particularly those which have perpendicular elevation, ought to be connected with the rod. The main portion of the great building erected for the World's Exhibition at Paris was entirely surrounded by a rod of iron, from which rose at intervals a series of lightning-conductors, the whole system being connected with the earth by means of four wells, one at each corner of the edifice.

The foregoing rules may serve as general guides for the erection of lightning-rods on ordinary buildings, but for the protection of a large complex structure, consisting of several parts, a special survey should be made, and the best form of protection devised which the peculiar circumstances of the case will admit.

Art. XLVI.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior;* by Raphael Pumpelly.

[Continued from pages 188 and 258.]

Chalcocite, Bornite, Whitneyite, Domeykite.—Two fissure-veins are known in the neighborhood of Portage Lake which carry these ores. They have been examined only very superficially; but it is a remarkable fact that the amygdaloids traversed by these veins contain only native copper. One of the fissure-veins, bearing both sulphides and arsenides of copper, enters the Grand Portage cupriferous amygdaloid bed, which bears only native copper, and remains in it with a changed direction for a short distance. The gangue of these veins is quartz, calcite and a carbonate of lime containing some iron and magnesia—ankerite?

The only other instance I have observed of the occurrence of copper in combination with sulphur, is in the fissure-vein of the Mendota property, near Lac la Belle. This vein appears to traverse the entire trappean series from Agate Harbor on the north to Lac la Belle.

Wherever this vein has been opened or uncovered, along the greater part of its course, north of the Mendota property, only *native* copper has been found; but when it enters a bed of conglomerate on the north flank of Mt. Bohemia, the little copper it contains is combined with sulphur in a very pure chalcocite. Where the vein passed from the conglomerate into the underlying amygdaloid, a fine deposit of chalcocite with calcite was found to have been formed, for a short distance, on both sides of the vein, between the two beds.

Still farther south the vein enters a mass of syenite, consisting of a pink triclinic feldspar, some hornblende and much chlorite, as an alteration-product of hornblende, and containing frequent impregnations of chalcopyrite, bornite, and, more rarely, chalcocite. In this syenite the vein and its many feeders carry bornite and considerable quantities of a bluish sulphuret of copper, in sheets ¼ to ¾ inch thick, which has a very crystalline structure and exhibits octahedral cleavage.*

Near the contact between the syenite and trap the latter rock is impregnated with magnetite, specular-iron, chalcopyrite and bornite. Excepting the syenite, wherever copper is found in the traps and amygdaloids on the Mendota property, it is in the metallic state. The occurrence of the sulphides and arsenides of copper in this isolated manner and in fissure-veins traversing

* Prof. Cooke, after a casual examination of this mineral, suggests that it is probably a pseudomorph of chalcocite after cuprite.

rocks more or less impregnated with metallic copper, seems to show a diversity of origin for the sulphur and arsenic on the one hand, and the copper on the other. It does not seem unreasonable to suppose the copper to have entered the vein-fissure from the adjoining rocks in solution, as carbonate, sulphate or silicate, and to have been then precipitated by sulphureted hydrogen and arseniureted hydrogen respectively. Or the copper may have been deposited in these as in the other veins, in the metallic state, and have been subsequently changed by the same gases. In the case of the pseudomorphous chalcocite, where the Mendota vein traverses syenite, cuprite must have been formed by the oxydation of chalcocite or of native copper, and the oxide must have been subsequently decomposed by sulphureted hydrogen.

The Huronian formation, which probably underlies all this region, contains in its upper members large amounts of carbonaceous matter in the form of graphite; the gases may have originated in a reduction of sulphates and arseniates by the carbon of these beds.

Among the pebbles in the Calumet conglomerate there is a variety of quartz porphyry, with a brown, compact, almost jaspery matrix, which only glazes slightly before the blowpipe. In this paste, there are numerous grains of dark quartz $\frac{1}{20}$–$\frac{1}{4}$ inch in diameter, and often more frequent crystals of flesh-red feldspar, apparently orthoclase,—$\frac{1}{16}$ to $\frac{7}{16}$ inches in length.

It not rarely happens, that in these flesh-red crystals there appear dirty green portions exhibiting the twine striation of a triclinic variety. The feldspar is hard and brilliant, but is nevertheless no longer intact; under the glass the crystals appear cavernous, 10 per cent or more of the substance being gone. This is the character of this porphyry in the freshest pebbles.

I have before me a pebble 4 inches in diameter, broken through the middle. It was the same variety of porphyry I have just described—the same brown matrix, with the same grains of quartz, and the same large crystals of orthoclase, often enclosing crystals of triclinic feldspar. But this pebble carries on its face the history of an extreme change. In the interior, where it is freshest, the matrix, still of the same brown color, has become so soft as to be easily scratched with the point of a needle. The quartz grains are highly fissured, and the surfaces of the fissures are covered with a soft light-green magnesian mineral. The feldspar, although it still resists the point of the steel needle, has generally lost its glance, and has an almost earthy fracture; it is lighter colored, and tends to spotted dirty-red and white. In places, specks of chlorite are

visible in the holes in the altered feldspar, and the cleavage planes often glisten with flakes of copper. As we go further from the middle of the specimen toward the original surface of the pebble, the matrix becomes much softer, though still with brown color and brown streak, and then changes to a soft green chloritic mineral, which whitens before the blow-pipe, and fuses on the edges to a grey glass. A little further from the center there is no longer a trace of the porphyry matrix: it is altered wholly to chlorite. The feldspar crystals are somewhat more altered here than they are in the middle of the pebble, but the quartz grains seem to have been in part replaced by chlorite. The change to chlorite is accompanied throughout by the presence of a large amount of copper. While in the interior of the pebble, the flakes of copper are confined to the cleavage planes of the feldspar, and the porphyry matrix exhibits scarcely a trace of the metal, the chlorite which has replaced the matrix contains in different parts of the specimen from 10 to 60 per cent, by weight, of copper.

In another pebble of the same porphyry, not only is the original matrix gone, but the usurping chlorite has been almost, if not wholly, replaced by copper; and we have as the remarkable result a quartz-porphyry, whose crystals of feldspar and grains of quartz lie in a matrix of metallic copper. There is still a very small amount of chlorite present, but it seems to have come from the change of the feldspar crystals and quartz grains.

In other pebbles of the same quartz-porphyry, containing, perhaps, less quartz, the alteration seems to have taken a somewhat different direction, or at least, the result before us is different. In the interior of the pebble, the matrix is of a darker and dirtier brown than in the previous cases, which may be due to the presence of manganese in the alteration product Going from the middle, the brown color changes rather abruptly to a dirty greenish-gray; the material also becomes softer, but it is earthy, with an earthy odor, and gritty to the touch. The change seems here to be in the direction of kaolinization.

The entire pebble is permeated with minute shining threads and plates of carbonate of lime. The lighter-colored portion contains considerable copper, while nearer the surface of the pebble it is largely replaced by that metal. Pebbles showing the various alterations described above are by no means rare. Many of them, from 1 inch to 1 foot in diameter, are found every day.

III. *Conclusions.*

We may be permitted to draw a few conclusions from the facts brought out in the observations thrown together in the foregoing pages.

I. The *Chlorite* of the melaphyr, and consequently the distinctive character of that rock, is due to the alteration of hornblende or pyroxene. This seems to have been the first step toward the production of melaphyr proper. *Laumontite*, which we find alike in the beds containing the least and in those containing the most chlorite, and occurring both diffused and concentrated in seams, appears to have been formed either contemporaneously with the chlorite, or as the next step in the process.

The next step appears to have been the individualization, in amygdaloidal cavities, of *non-alkaline silicates*, viz: *laumontite*, *prehnite*, *epidote* respectively, according as the conditions favored the formation of one or the other of these.

Following these came the individualization of *quartz* in these cavities.

Perhaps we may be warranted in considering these minerals, together with the lime of the calcite that more rarely occurs in this portion of the series, as chiefly due to the decomposition of the pyroxenic ingredient of the rock.

So far as we may infer from the tabulated results, the concentration of *copper* in the amygdaloidal cavities does not appear to have begun till after the formation of the quartz.

In this part of the series falls also the formation of a chloritic or green-earth mineral, which in some manner has displaced prehnite, quartz, calcite, and with which copper, when present, appears to stand in intimate relation. Subsequently to this came the individualization of the alkaline silicates, viz: analcite, apophyllite, orthoclase. Here also seems to belong the formation of datolite.

The alkaline silicates represent the period of decomposition of the labradorite ingredient of the original rock, and when they occur in the mass of the rock (as distinguished from veins), it is only where the alteration of the rock has proceeded so far, that the amygdaloidal form has merged into the brecciated through the enlargement and union of the cavities.

The fact that calcite occurs at almost every step in the paragenetic series, and forms one of the most common of the secondary minerals, is proof that carbonic acid was very generally present throughout the whole period of metamorphism; it was probably the chief mediating agent in the processes, without being sufficiently abundant to prevent the formation of silicates.

II. The change of pyroxene to chlorite, as illustrated on an immense scale in the formation of the melaphyr, and the displacement of feldspar and quartz—quartz-porphyry—by chlorite as exhibited in pebbles of the conglomerate, point to an extremely important line of investigation for the chemical geologist. The alteration of the pebbles appears to have fol-

lowed two different directions according to the ruling conditions, viz: either toward chlorite or toward kaolinization; and as the result of the latter process is impregnated with calcite while the result of the former is free from carbonates, it would seem that the direction was determined by the presence or relative freedom from free carbonic acid. The deposition of calcite, if formed from the acid carbonate, would set free sufficient carbonic acid to prevent the formation of silicates of iron and magnesia.

III. *Copper*, wherever we can detect it with the eye, has already gone through a partial concentration. The presence of this metal in minute quantity in the sandstones of Lake Superior, is made evident by the stains of carbonate which form on the cliffs of the "Pictured Rocks." It is found here and there in the less amygdaloidal melaphyr in minute specks and impregnations, or even in a more concentrated form as thin sheets occupying the joint-cracks.

These occurrences increase in frequency in proportion as the rock is more amygdaloidal; in other words, the copper is more concentrated in those portions of the beds where the chemical change has been greatest. Where the rock has not passed beyond the strictly amygdaloidal stage, the copper occurs in the amygdules traversing these in flakes, or coating them in a film of greater or less thickness, to such an extent as to form from $\frac{1}{4}$ per cent to 3 per cent by weight of the rock over considerable areas. Finally, in those beds where the metamorphism has proceeded to such an extent as to wholly replace large portions of the amygdaloid by secondary minerals, epidote, calcite, quartz, chlorite, laumontite, etc., there the copper occurs in masses of many pounds, and sometimes of several tons weight, and in forms equalled in their irregularity only by those of the masses of secondary minerals accompanying the metal.

In each and all of these positions we find that the deposition of the copper took place subsequently to the decomposition and removal of a portion of the rocks, and subsequently to the deposition of laumontite, epidote, prehnite, and quartz, where these accompany it.

In all this we have direct evidence of the movement of some salt of copper in wet solution, and the concentration of the metal by accumulating deposition in places where the precipitating agent existed.

The Quebec group, to which these rocks belong, and which consist in various places of undoubted sedimentary strata exhibiting every degree of metamorphism, is as strongly characterized by copper as the Galena limestone is by lead.

Except in the melaphyrs of Lake Superior, the copper, so widely diffused in the strata of the Quebec group, exists either

in the various suphurets, or as oxidation products of these. Indeed we cannot well suppose the copper to have been deposited in submarine formations in any other condition than as sulphuret. Nor can we suppose it to have taken any other form permanently, so long as unoxidized organic matter remained in the beds. An oxidation of the sulphuret would be followed by reduction of the resulting sulphate to new sulphurets around the organic remains. In this way we may suppose the simplest and most common form of concentrated deposits —the impregnations—to have originated, as well as the farther enrichment of particular beds or zones—*fahlbands*—which may represent strata which were originally richer in organic substances, or which may have retained these longer than the other beds.

The trappean series of Keweenaw Point differ from the general character of the rocks of the Quebec group, both in lithological constitution and in having the copper in the metallic state. It is still an open question whether the trap which formed the parent rock of the melaphyr was an eruptive or a purely metamorphic rock. If it was eruptive, it was spread over the bottom of the sea in beds of great regularity, and with intervals which were occupied by the deposition of the beds of conglomerate and sandstones.

But the general diffusion of copper through the varied rocks of the Quebec group, speaks for a marine origin for the metal in these traps. It should seem probable that the copper in the melaphyrs was derived by concentration from the whole thickness of the sedimentary members of the group, including the thousands of feet of sandstones, conglomerates and shales which overlie the melaphyrs and including melaphyrs also—and especially, if these are purely metamorphic.

Among the most interesting questions connected with the occurrence of the copper, are those touching its condition previous to concentration during the amygdaloidal stage of metamorphism, the chemical combination by which this concentration was effected, and the character of the precipitating agent.

The great persistency of metallic sulphurets through the usual processes of metamorphism, and the almost universal association of sulphur with copper in crystalline rocks, renders it perhaps probable that this was here also the combination in which the metal was diffused, or rather, very partially concentrated. Traces of sulphur detected by Mr. Hochstetter in the melaphyr contiguous to the Hecla conglomerate point also in this direction, considering that the only acids generally present in the melaphyrs are silicic and carbonic acids, and if we add sulphuric acid as an oxidation product of the sulphurets, our choice of the form of solution, by which the final concentration

was effected, should seem to be limited to silicates, carbonates, and sulphates of copper. Probably all of these combinations took part in the process, but while we may consider the translocation of the copper to have been initiated by the sulphate, this salt must have been so soon decomposed by the abundant acid carbonate of lime* as well as by the alkaline silicates, that we cannot readily suppose the sulphate† to have generally effected the final concentration of large deposits. It is more probable that this was accomplished by the more permanent solutions of carbonate and silicate of copper respectively, as the circumstances favored. The position of the metallic copper in the paragenetic series shows it to have been deposited after the non-alkaline silicates, and before the formation of the alkaline silicates, i. e., after those minerals which resulted from the decomposition of the pyroxenic constituent of the rock, and before those which were formed by the destruction of the feldspar. Now this is what we should expect if we suppose the pyroxenic rock to have been altered to its present condition under the coöperation of water carrying carbonic acid and some free oxygen, because the oxygen must have been employed in oxidizing the carbonate of iron resulting from the decomposition of the pyroxene;‡ the oxidation of the sulphuret of copper could not, therefore, take place until the pyroxene had so far disappeared as to leave a relative excess of oxygen as compared with the amount of ferrous salts exposed to a higher oxidation. Throughout its deposits the copper exhibits a decidedly intimate connection with delessite, epidote and green-earth silicates, containing a considerable percentage of peroxide of iron as a more or less essential constituent; while among the other silicates, viz: analcite, laumontite, datolite, prehnite, only the last named, which alone seems subject to a considerable replacement of its alumina by ferric oxide, is especially favored by copper. This association is so invariable and so intimate that one is forced to the conclusion that there exists a close genetic relation between the metallic state of the copper and the ferric condition of the iron oxide in the associated silicates; that the higher oxidation of the iron was effected through the reduction of the oxide of copper and at the expense of the oxygen of the latter.

As regards the green-earth and that variety of chlorite or delessite which is intimately associated with the copper, they either immediately follow the copper in point of age or are contempo-

* A coating of gypsum covering very thin sheets of copper from the jointing-cracks of the melaphyr contiguous to the Hecla conglomerate, may be due to this decomposition, followed by the reduction of the copper.

† Compare Bischof Chem. u. Phys. Geol., I, p. 52, and III, p. 716.

‡ The result of this oxidation is seen in the brick-red color of the amygdaloids and in the brown color and spots of many of the melaphyr beds.

raneous with it, and they may be looked upon as having been formed under the influence of this reduction. Where copper is associated with prehnite it is invariably younger than the latter, a fact which would seem at the first glance to oppose the supposition that there is any relation between the peroxide of iron in the zeolite and the deposition of the copper. But we have seen that prehnite undergoes a change to delessite; we find these pseudomorphs in every stage of the process from the first green discoloration on the cleavage planes to the amygdule of delessite with prehnite structure. Now may we not consider the presence of iron in prehnite generally to be due to a beginning change, and the deposition of native copper in the Lake Superior prehnites to be partially or wholly correlated with the higher oxidation of the iron? In at least very many instances, if not in all, the deposition of the copper has been a result of a process of displacement of preëxisting minerals. In some rare instances the metal retains the form of its more or less remote predecessor, as in the pseudomorphs after some mineral (clay?) after laumontite.

Nowhere is this displacement more apparent than in the cupriferous conglomerates. In these the cement is the home of the metal, and in some places, as in portions of the Hecla and Calumet mines, it is wholly replaced by it; copper forming 20 to 50 per cent, by weight, of the rock. In these instances either chlorite or epidote is associated with the copper as minerals formed since the deposition of the conglomerate, while calcite very frequently replaces the cement in barren portions of the bed.

The cement of the conglomerates is of the same materials as the pebbles in a more comminuted form. The displacement of the whole mass of quartz porphyry in large pebble by chlorite and copper described above, is probably an illustration of the manner in which the cement was displaced on a more extended scale.

The absence of the ores of the baser metals—lead, zinc, nickel, etc., from the deposits of the trappean series, while they are present in the less metamorphosed rocks of the Quebec group in other localities, may be due to the greater intensity of the chemical action to which the melaphyrs have been subjected; an intensity which may be measured by the extent to which the process of concentration has been carried. Concentration is a process of removal relatively speaking, and concentrated deposits are accumulated masses of material arrested in the drainage channels of rock masses by the action of competent forces; if the arresting cause is absent from a given region, the removal will continue to another where it is present. If causes exist which are able to arrest one class of the substances in the passing solution, and are powerless as regards another class, then a separation will occur between the two classes.

Now, copper and silver belong to a class distinct from the baser metals in that, by reason of their smaller affinity for oxygen, they are more readily reduced to the metallic state, the condition of greatest permanence in presence of the usual reagents to which they are exposed. If the arresting cause of these metals was, as we have supposed, their reduction by protoxide of iron, it is a cause which would have been powerless as regards the salts of the baser metals, and we may suppose these to have continued in solution till they reached some region where they were arrested by the presence of organic matter, or of sulphureted hydrogen, etc.

ART. XLVII.—*Observations on the color of Fluorescent solutions*—No. II; by HENRY MORTON, Ph.D., President of the Stevens Institute of Technology.

SINCE the publication of my article on the above subject, in the August number of this Journal, I have discovered a curious action which, while it in no respect affects my general conclusions, nor the main observations on which they were founded, throws out one of the corroborative experiments by which I thought that they might be established when a spectroscope was not at hand.

Obtaining some very anomalous results of late, I was led to mistrust the action of the Geissler tubes in which the solutions had been examined.

They were of the ordinary kind of jacketed spirals, selected as being nearly identical in size and other particulars.

It had been observed from the first that the internal spiral gave a faint blue fluorescence which could only be seen on close inspection; and in all cases, the tube being but partly filled, it was considered that a light appearing in the part covered by the fluid, many times more bright than that from the uncovered part of the spiral, was sufficient evidence of fluorescence in the liquid.

Late experiments have, however, proved that this was not so. Any liquid, however devoid of fluorescent properties, gives all the appearance of fluorescing in these tubes, and on a little thought the cause of this became clear.

The only fluorescent light that can be seen from the glass of the spiral is that which comes off tangentially from the outer surface, that emitted radially being marked by the bright electric discharge behind.

In passing from the glass to air, most of the light will suffer total reflection at the outer surface of the glass, but if water or

any other liquid is substituted for the air, its greater refracting power (approaching that of glass) will diminish the above named action, so that much more of the light will reach the eye. The truth of this explanation was supported by the observation that the nearer the index of refraction in the liquid came to that of glass, the brighter was the light seen through it, while a liquid of higher refraction, like carbon bisulphide, seemed a little to weaken the effect by diffusion.

This fact renders of no account the observations before made on filtered and diluted solutions of turmeric, but a fresh observation with the spectroscope on tubes free from fluorescence has fully confirmed my former conclusions as to the true color of fluorescence in this liquid.

No correction need be applied to the description already published in the case of the asphalt solution, but I may add to what was there stated another striking example.

If one of the little Geissler tubes containing nitrogen, called "spectrum tubes," be jacketed by means of a perforated cork and a large glass tube, and the jacket filled with pure or non-fluorescent benzine, then illuminating the tube, and with a pipette dropping in that petroleum product called "cosmoline" (a lubricating oil made by E. H. Houghton, of Philadelphia), each drop will appear of a rich blue as it dissolves in the benzine, which soon acquires a magnificent blue fluorescence. Increasing, however, the quantity of cosmoline oil until its color begins to take effect, the tint of the fluorescence gradually changes to a rich green.

By a little care a blue solution may be superposed on a green one in the same tube.

Another semi-solid preparation of cosmoline, which has a very light color, gives a solution with benzine fluorescing of a magnificent blue.

I have this substance now under investigation, and hope soon to be able to make some further observations upon it.*

Returning to the solutions of turmeric, I have found that the fluorescent body in that substance is not its essential oil nor its brown coloring matter, but either the yellow coloring matter itself, or something so closely allied to it in solubility that I have thus far been unable to effect any separation.

In connection with this, let me say that I am much indebted to Mr. Robt. F. Fairthorne, of Philadelphia, who has aided me greatly in the preparation of the various constituents of turmeric in a state of purity.

In my former paper I mentioned that uranium nitrate in solution gave a very faint fluorescence.

* Mr. Houghton tells me that "cosmoline" is prepared from crude petroleum by evaporation in vacuo and filtration through animal charcoal only, without any chemical treatment.

This appearance I now find was due entirely to the above explained action of the tube, and a number of carefully conducted observations now convince me that this substance, while it fluoresces so vividly in the solid state, loses that property entirely when in solution.

I have also found that a saturated solution of acid quinine sulphate has its fluorescence much *increased* by dilution.

Lastly, let me remark that I by no means assert that *all* solutions fluoresce blue, but simply those which I have examined. There are many which I have as yet been unable to procure or study, whose relations in this respect I hope soon to investigate.

ART. XLVIII.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XVI.—*On the Distribution of Marine Animals on the southern coast of New England;* by A. E. VERRILL.

IN connection with the investigations concerning the fisheries under the direction of Professor S. F. Baird, U. S. Commissioner, thorough explorations of the adjacent waters were undertaken in order to ascertain the character of the bottom, and the distribution of the lower animals, especially of those that furnish food for certain fishes. The Fish Commission had its headquarters at Wood's Hole, Mass., situated on the point of land between Vineyard Sound and Buzzard's Bay. In addition to the shore collections, extensive and systematic dredging operations were undertaken by means of a steam-launch in the waters of Vineyard Sound and Buzzard's Bay, and by the aid of a U. S. Revenue Cutter, the steamer "Moccasin," the dredgings were carried outward to the deeper parts of Muskeget Channel, situated off Martha's Vineyard, and from thence to a point off the mouth of Buzzard's Bay.* These explorations were made by means of dredges of several different sizes, of the usual forms; a rake-dredge of novel construction, especially adapted to soft muddy bottoms; an iron frame to which unraveled ropes, or "tangles," were attached for use on rocky bottoms; a large trawl-net; surface towing-nets for swimming creatures, etc.† The points where dredgings were made were carefully located on Coast Survey charts, and were sufficiently numerous to give a satisfactory knowledge of the nature of the bottom and its inhabitants throughout the region explored. The total number of hauls of the dredges, during the three

* The dredgings in the first part of the season were made under the direction of Mr. S. I. Smith, and later by Professor J. E. Todd, Professor A. Hyatt, Dr. A. S. Packard, and the writer, all more or less aided at various times by other naturalists, and especially by Dr. W. G. Farlow, who collected the algæ.

† Some of these instruments will be described in a future number of this Journal.

months, was about four hundred. The surface dredging also yielded many things of great interest.

At this time I wish to call the attention of zoölogists to one of the most important of the results of these investigations, leaving a full account of the large and valuable collections for another occasion. The discovery referred to is that while the shores and shallow waters of the bays and sounds, as far as Cape Cod, are occupied chiefly by southern forms, or the Virginian fauna, the deeper channels and the central parts of Long Island Sound, as far as Stonington, Conn., are inhabited almost exclusively by northern forms, or an extension of the Acadian fauna.

There is also a corresponding difference in the temperature of the water, the change in some cases amounting to 5° F., both at the surface and bottom, within a distance of two miles and without much change in the depth. And consequently there must be an offshoot of the arctic current setting into the middle of the Sound, although the shores feel the influence of the Gulf Stream, as shown by the occurrence of southern forms of pelagic animals in their waters.

The shores of Buzzard's Bay and Vineyard Sound present nearly all varieties of stations, and are, therefore, favorable for collecting. They are occupied, except on some of the outer islands, by an assemblage of animals characteristic of the coasts farther south, and known as the *Virginian fauna*. A few northern forms occur, however, on the rocky shores, which do not extend as far as New Haven. Among these *Purpura lapillus* is most conspicuous. This shell is associated there with *Eurosalpinx cinerey*, in about equal numbers, but at New Haven the latter occurs alone, while on the northern coasts of New England the *Purpura* is found unaccompanied by the other, which is rarely found north of Cape Cod. But in nearly all other respects the littoral fauna is very similar to that of the vicinity of New Haven, or the coasts farther south, as far as Cape Hatteras, making allowance only for differences in the stations, and especially for the absence of rocks south of New York.

In Vineyard Sound and Buzzard's Bay the water is everywhere shallow, usually from 3 to 8 fathoms deep, and rarely exceeding 12 or 14 fathoms, even in mid-channel. In Vineyard Sound the bottom is generally sandy, and extensive reefs of shifting sand are numerous, and often nearly destitute of life. But extensive regions of gravelly and shelly bottoms occur, and these are often almost completely covered by several species of compound ascidians, growing in large masses. One of these, which forms large hemispherical or irregular masses, made up of an aggregation of long slender colonies, united together at their bases and usually thickly covered

throughout with sand, is very abundant, often entirely filling the dredge with masses up to six inches in diameter. This is the *Amouroucium pellucidum* Verrill. Another one, nearly as abundant, forms smooth, cartilaginous masses in the form of flat lobes, crests, and plates, sometimes two feet long and about an inch thick, the surface covered with stellate colonies, while the color of the masses is of a delicate bluish or sea-green tint by reflected light, although yellow by transmitted light. This is *Amouroucium stellatum* V., described with the last in a former number of this Journal. A third species* of the same genus is also common, although still undescribed. This forms smooth gelatinous masses, varying from light orange to pale yellowish in color, with beautifully stellated colonies over its upper surface. With these were several simple ascidians, chiefly *Cynthia partita*† Stimp., and *Molgula Manhattensis* V., while creeping over them was a beautiful green species of *Perophora*,‡ which is the first representative of the social ascidians discovered on our coast. This species also occurred in abundance on the piles of the government wharf at Wood's Hole, associated with the three last named. In the interstices of *A. pellucidum* were numerous annelids of several species, and growing upon or with the ascidians were many species of hydroids, bryozoa, and sponges. Among the sponges a massive sulphur-yellow species (*Spongia sulphurea* Desor) is very conspicuous. While young this species perforates and destroys dead bivalve shells, but later in life grows up into hemispherical or irregular masses. Upon the same bottoms were found the common southern greenish star-fish (*Asterias arenicola*), *Amphipholis elegans*, *Gouldia mactracea*, *Eulima oleracea* on *Thyone briareus*, *Anachis avara*, *Columbella lunata*, *Cancer irroratus*, *Libinia canaliculata*, *L. dubia*, *Eupagurus pollicaris*, *E. longicarpus*, and many other less common species. On rocky and stony bottoms, and especially in the tide-way of the channel at Wood's

* *Amouroucium constellatum*, sp. nov. Masses thick, turbinate, often encrusting, surface usually convex, smooth, substance firm, gelatinous, translucent, but softer than in *A. stellatum*. Systems stellate, circular, oval or elliptical, often elongated, or irregular and complex. Zoöids much elongated, slender, the branchial tube short with six rounded lobes. Branchial sac elongated. Color of the masses usually light orange-red, varying to yellowish and pale flesh-color; the branchial orifices with six radiating white lines. Zoöids generally orange-yellow; the orifices and tubes with upper part of mantle bright orange, or lemon-yellow; branchial sac usually flesh-color or pale yellow, sometimes bright orange; stomach with bright orange-red glandular ribs; mantle with minute opaque white specks.

† *Cynthia stellifera* V. proves to be a depressed variety of this species.

‡ *Perophora viridis*, sp. nov. Individuals small, about ·10 to ·12 of an inch high, connected by slender stolons, and thickly covering the surfaces over which they creep. Test compressed, seen from the side scarcely higher than broad, oval, elliptical, or subcircular, often one-sided or distorted, with a short pedicle or subsessile at base. Branchial orifice large, terminal; anal lateral or subterminal, both a little prominent, with about 16 angular lobes, alternately larger and smaller. Test transparent; mantle beautifully reticulated with bright yellowish green; intestine yellow.

Hole, the southern purple sea-urchin (*Echinocidaris punctulata*), the orange star-fish (*Cribrella sanguinolenta*), the green star-fish, the coral (*Astrangia Danæ*), and many other interesting species occurred. All the species referred to, excepting the widely diffused species of *Cribrella* and *Amphipholis*, are either characteristic southern forms or else species that are not yet known except from the region explored. Several species were also obtained in Vineyard Sound which had not previously been found so far northward. Among these the flat sea-urchin with five perforations (*Mellita pentapora*) is especially worthy of mention, as it has hitherto been regarded as peculiar to the Carolinian fauna.* The free-swimming forms taken at the surface in this region were also numerous, and are likewise chiefly southern species, or if new they belong to southern types. Among the most interesting were *Salpa Cabotii*, which occurred in vast quantities about the first of September, and was found in abundance off Gay Head, as well as in the Sound; a splendid species of *Saphirina*, reflecting brilliant blue and red colors like a fire opal, which occurred mingled with the *Salpæ;* a new free-swimming crab; *Idotæa robusta* Kr.; innumerable young lobsters, crabs, and shrimp, in the zoea and megalops stages of growth; numerous jelly-fishes, among which *Mnemiopsis Leidyi* was perhaps the most abundant, but a species of *Cyanea* and *Dactylometra quinquecirra* were common, and both frequently gave shelter to several young "butter-fishes" (*Poronotus triacanthus*) of all sizes, from those just hatched up to two inches or more in length. In some cases twenty or more were found together under one jelly-fish. They also occurred, in the evening, under *Zygodactyla Grœnlandica* earlier in the season. The "Portuguese-man-of-war" (*Physalia arethusa*) was met with several times. Two Pteropods not before recorded from the United States coast were obtained,—one of them (*Stiliola* sp.) living, associated with *Salpa;* but of the other (*Cavolina tridentata*) the shells only were dredged, but in a very fresh condition.

In the deeper outer channels, as between Gay Head and Nomans-land, and at nearly all points outside of the latter, where the water is more than ten fathoms in depth, the fauna is very different from that of the sounds and bays, and closely resembles that of Massachusetts Bay and the coast of Maine. The difference in the temperature of the water is also well-marked. The surface temperature, during the latter part of August, was 69° to 71° in Vineyard Sound. On Sept. 9th, in the mouth of Vineyard Sound, west from Gay Head, the surface temperature was 67° F., and the bottom, in 15½ fathoms, was 63°; but pro-

* This and *Lytechinus variegatus* were found by the writer, Mr. S. I. Smith and Prof. J. E. Todd at Great Egg Harbor, N. J., last spring, but they are very rare at that locality.

ceeding about two miles farther out, off No-mans-land, the surface temperature was 62°, and the bottom, in 18 fathoms, was 58½°, showing a decrease of 5° within this short distance, both at the surface and bottom. A few miles farther out, at the same depth, the bottom temperature was 57°, which was the lowest temperature obtained. A short distance west of No-mans-land, on a gravelly bottom in 11 fathoms, where cod-fish are caught in winter, the temperature was 63° at the surface and 59° at the bottom. Off the mouth of Narragansett Bay, about sixteen miles south from Newport, the depth over a limited area is 29 fathoms, which was the deepest water found. At this locality the surface temperature was 62° and the bottom 59°. The bottom, in these deeper waters, was generally composed of soft mud, filled with innumerable tubes of worms and Amphipod crustacea, among which a species of *Ampelisca*, which makes a soft flabby tube, two or three inches long and covered with mud, is extremely abundant. At the last named locality numerous specimens of the rare and beautiful *Epizoanthus Americanus* V. was found coating the shells inhabited by hermit-crabs (*Eupagurus Bernhardus*) and finally absorbing the shells entirely. This remarkable Actinian has been found previously only on two occasions,—first on a deep bank off the coast of New Jersey, by Capt. Gedney; and since in deep water off Massachusetts Bay. With this was also found a rare Holothurian (*Molpadia oölitica*), previously known only from specimens taken from fish stomachs.

The various muddy bottoms in the deeper and colder areas yielded nearly the same assemblages of animals, most of which are either strictly northern types, many of them not before observed so far south; or else species of wide range extending much farther north as well as south. Among those of special interest are the following: of RADIATA, *Edwardsia farinacea* V., previously known only from the Bay of Fundy, *Thyonidium* sp.; of MOLLUSCA, *Molgula pilularis* V. and *Glandula mollis* Stimp., both known before only from the Bay of Fundy, *Cyprina Islandica*, *Cardita borealis*, *C. Novangliæ*, *Yoldia sapotilla*, *Y. limatula*, *Nucula proxima*, *N. delphinodonta*, *Cardium pinnulatum*, *Astarte quadrans*, *A. castanea*, *A. lutea* (?) Perkins, *Lyonsia hyalina*. *Anatina papyracea*, *Lucina filosa*, *Callista convexa*, *Crenella glandula*, *Modiolaria nigra*, *M. corrugata*, *Pecten tenuicostatus* (young = *P. fuscus* Lins.), *Buccinum undulatum*, *Chrysodomus pygmæus* (large and abundant), *Crucibulum striatum*, *Margarita obscura*, *Cylichna alba;* of ANNELIDS, *Clymene torquata* Leidy, *Ophelia simplex* Leidy ?, *Trophonia* sp., *Sternaspis fossor*, *Aphrodite aculeata* (large and common), *Nephthys* (large species), *Sipunculus Bernhardus*, and species of *Nereis*, *Lumbriconereis*, *Aricia*, etc.; of CRUSTACEA, species of *Ampelisca* (abundant),

Unciola irrorata, and several other Amphipods, *Crangon vulgaris*, *Pandalus annulicornis*. On sandy bottoms *Echinarachnius parma* was very abundant, as it was, also, everywhere in the sounds, for it is a widely diffused species, occurring as far south as Great Egg Harbor; *Molgula arenata* St. also occurred, with a few other species of interest. A large species of sandy *Foraminifera*, often a quarter of an inch in diameter, was abundant. In the channel between Gay Head and No-mans-land the bottom is gravelly and stony, and here some very interesting species were found; among the RADIATA were *Alcyonium carneum* Ag., *Edwardsia* (new species), *Grammaria gracilis* St., and many other hydroids, *Cribrella sanguinolenta*, *Asterias vulgaris* V., *Ophiopholis aculeata* Gray, *Euryechinus Drobachiensis* V.; of ASCIDIANS, *Amouroucium pallidum* V., *Molgula papillosa* V., *Cynthia carnea* V., *C. hirsuta* Binney, *C. partita* St., all northern species except the last; of shells many of the northern forms already named and some additional species; of CRUSTACEA, *Eupagurus Bernhardus*, *Cancer borealis* (thrown on shore and fragments dredged), *C. irroratus*, with numerous *Amphipods*.

The brief lists of species given above are quite sufficient to show the marked northern character of the fauna in the deeper waters of this region. Several of the northern shells enumerated above have also been dredged by Mr. Sanderson Smith in Gardiner's Bay, L. I., and some of them have long been known from Montauk Point. Mr. Linsley, in his catalogue of the shells of Connecticut,* also records many of the same northern species with a few additional ones, from Stonington. I have been informed by Mr. H. C. Trumbull, who collected the shells attributed to Stonington, that all these northern species were obtained by him from the stomachs of haddock, &c., which were taken within a few miles of Stonington. This would indicate that the northern cold current has a decided influence as far westward as that locality, beyond which its influence has not yet been traced.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On nitrous and hyponitric acids.*—HASENBACH has repeated the experiments of Nylander on the nature of the red vapors formed in the oxidation of arsenous by nitric acid. By condensing these vapors, Nylander obtained a blue liquid boiling at 13° C., which appeared to have the formula $N\Theta_2$, and therefore to be isomeric with hyponitric acid. Hasenbach employed an apparatus constructed entirely of glass, and dried the liquid product ob-

* This Journal, I, vol. xlviii, 1845.

tained with calcined cupric sulphate. The deep blue liquid obtained began to boil at 2° C., giving off much nitric oxide; the thermometer then rose rapidly to 10° C.; between 10° and 13° but little nitric oxide was given off. Between 13° and 22° the temperature rose rapidly, and at 22° the remaining portion of liquid passed over with the brown-red color of hyponitric acid. As the author could obtain no liquid with a constant boiling point between 10° and 13°, this portion of liquid was analyzed and found to have nearly the composition of hyponitric acid, $N\Theta_2$. The vapor density of this liquid, 2·177, also corresponded with that of hyponitric acid, which is 2·061 as calculated from the formula. The vapor when passed through a heated tube became colorless, but the color appeared again in the colder portion of the tube. Further investigation proved that the compound boiling between 10° and 22° was a mixture of much hyponitric with a little nitrous acid. The general results of the author's investigation are as follows:

(1.) The assumption of Nylander that in the oxidation of arsenous by nitric acid, of density 1·33, an isomer of hyponitric acid is formed, is without foundation. In this case, according to the concentration of the nitric acid, either hyponitric acid, or a mixture of nitrous and hyponitric acid, is formed.

(2.) Hyponitric acid and nitric oxide unite at a high temperature to form nitrous acid, which may in this manner be prepared chemically pure.

(3.) Hyponitric acid and chlorine under the same circumstances unite to form chloronitric acid, $N\Theta_2Cl$.

(4.) Bromonitric acid, $N\Theta_2B_2$, could not be obtained pure by this process, as the product is decomposed by boiling.

(5.) Iodine and hyponitric acid do not combine at a high temperature.

(6.) Cyanogen and hyponitric acid give, with the aid of heat, a highly explosive compound, perhaps cyanonitric acid, $N\Theta_2Cy$.

(7.) Chlorine, bromine and cyanogen do not unite in the cold with hyponitric acid, or do so only to a very limited extent.

(8.) Nitrous acid and oxygen unite at ordinary temperatures to form hyponitric acid.

(9.) Sulphurous acid and carbonic oxide unite with hyponitric acid, even at a low temperature, to form compounds not further investigated.

All these facts speak in favor of the assumption that the molecule of fluid hyponitric acid is $\left\{\begin{matrix} N\Theta_2 \\ N\Theta_2 \end{matrix}\right.$; that of the vapor above 100°, on the contrary, $N\Theta_2$.—*Journal für prakt. Chemie, Band* iv, p. 1. (New Series.) W. G.

2. *New method of separating magnesia from potash and soda.*—Scheerer separates the alkaline metals from magnesia in the following manner: The solution of the chlorides of the bases which may contain ammoniacal salts is to be evaporated, in a platinum vessel, not quite to dryness; a larger quantity of powdered ammonic oxalate is then to be stirred in, the whole heated to perfect

dryness, and finally gently ignited, care being taken to expose every portion of the saline mass to the same high temperature. The mass is then to be heated with water—heated to the boiling point and filtered. The magnesia remains on the filter as carbonate, while the alkalies are present in the filtrate as carbonates perfectly free from magnesia. The separation here depends, partly upon the formation of magnesic oxalate, which is decomposed by ignition into carbonate, partly upon the fact that the temperature at which ammonic oxalate is decomposed is higher than that at which ammonic carbonate is volatalized. The ammonic oxalate must of course be so pure as to leave no residue on ignition. In the presence of sulphuric acid the method is not applicable, probably because the ammonic sulphate is decomposed after the oxalate. —*Journal für prakt. Chemie*, *B.* iii, p. 476. W. G.

3. *On the methylation of the phenyl group in anilin.*—BERTHELOT observed some years since that small quantities of ethylamin are formed by the action of alcohol upon ammonic chloride at a high temperature. The reaction, which in this case takes place with great difficulty, was employed by Bardes, chemical director of the anilin color factory of Poirrier and Chappat in Paris, for the production of methyl anilin, dimethyl anilin, ethyl anilin and diethyl anilin, methylic or ethylic alcohol and chlorhydrate of anilin being heated together. In this reaction, however, other products are formed at the same time with the salts above mentioned, and these have been examined by Hofmann and Martius, who operated upon very large quantities of material, repeating the process twice in succession upon the same material. The very beautiful and interesting results of this investigation are as follows: The methylation or ethylation takes place in two distinct phases, the first being the introduction of methyl or ethyl into the phenyl-ammonia; the second, the replacement of the hydrogen of the phenyl itself by methyl or ethyl. So far as the final results are concerned, these reactions may be expressed by the equations:

$$\left.\begin{array}{l}
\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{H}\\ \text{H}\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\Theta=\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{H}\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\Theta\\
\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{H}\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\Theta=\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\Theta
\end{array}\right\}\text{1st phase.}$$

$$\left.\begin{array}{l}
\left.\begin{array}{l}\text{Є}_6\text{H}_5\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\Theta=\left.\begin{array}{l}\text{Є}_6\text{H}_4(\text{ЄH}_3)\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\Theta\\
\left.\begin{array}{l}\text{Є}_6\text{H}_4(\text{ЄH}_3)\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{ЄH}_3\\ \text{H}\end{array}\right\}\Theta=\left.\begin{array}{l}\text{Є}_6\text{H}_3(\text{ЄH}_3)_2\\ \text{Є H}_3\\ \text{Є H}_3\end{array}\right\}\text{N.HCl}+\left.\begin{array}{l}\text{H}\\ \text{H}\end{array}\right\}\Theta
\end{array}\right|\text{2d phase.}$$

It can, however, scarcely be doubted that methylic chloride and water are always formed first, and that methylic chloride is the true agent of substitution. In the basic oils submitted to examination, the authors discovered besides dimethyl anilin four other dime-

thylated monamines—namely, dimethylated toluidin, xylidin, cumidin and cymidin; in symbols the compounds:

Dimethyl—

$$\text{Anilin,}\quad \left.\begin{matrix}C_6H_4\\(CH_3)_2\end{matrix}\right\}N.$$

$$\text{Toluidin,}\quad \left.\begin{matrix}C_7H_7\\(CH_3)_2\end{matrix}\right\}N=\left.\begin{matrix}C_6H_4(CH_3)\\(CH_3)_2\end{matrix}\right\}N.$$

$$\text{Xylidin,}\quad \left.\begin{matrix}C_8H_9\\(CH_3)_2\end{matrix}\right\}N=\left.\begin{matrix}C_6H_3(CH_3)_2\\(CH_3)_2\end{matrix}\right\}N.$$

$$\text{Cumidin,}\quad \left.\begin{matrix}C_9H_{11}\\(CH_3)_2\end{matrix}\right\}N=\left.\begin{matrix}C_6H_2(CH_3)_3\\(CH_3)_2\end{matrix}\right\}N.$$

$$\text{Cymidin,}\quad \left.\begin{matrix}C_{10}H_{13}\\(CH_3)_2\end{matrix}\right\}N=\left.\begin{matrix}C_6H\,(CH_3)_4\\(CH_3)_2\end{matrix}\right\}N.$$

The terminal member of this group is still wanting, and would have the formula:

$$\left.\begin{matrix}C_{11}H_{15}\\(CH_3)_2\end{matrix}\right\}N=\left.\begin{matrix}C_6(CH_3)_5\\(CH_3)_2\end{matrix}\right\}N.$$

The authors remark that the names selected do not necessarily imply that the compounds are identical with those already known, since they may be only isomeric with them. Thus the xylidin already known may not give by methylation with methylic iodide a dimethyl xylidin identical with the above, but only one isomeric with it. Thus we already know a solid and a fluid modification of toluidin. By treatment with methylic iodide, solid toluidin yielded a dimethyl base, which in many respects resembled that mentioned above, but which yet did not appear to be certainly identical with it, although the tertiary monamines derived from both bases appeared to exhibit no differences whatever. The authors promise a further investigation of the whole subject, and chemists will look with the greatest interest for their results.—*Berichte der Deutschen Chem. Gesellschaft, Jahrgang* iv, p. 742. W. G.

4. *On the derivatives of hydric phosphide which correspond to ethylamin and diethylamin.*—A. W. Hofmann has succeeded in obtaining phosphorus compounds corresponding to ethylamin and diethylamin. The process consists in digesting an alcoholic iodide with iodide of phosphonium and a metallic oxide. When, for instance, one part by weight of zinc-white, four of iodide of phosphonium, and four of iodide of ethyl, are digested together for six to eight hours, at a temperature not exceeding 150° C., a nearly white crystalline mass is obtained, which is chiefly the iodide of ethly phosphin, the reaction being expressed by the equation:

$$2C_2H_5I+2Ph_4I+ZnO=2P(C_2H_5)H_3I+ZnI_2+OH_2.$$

In this case, however, a certain quantity of diethyl phosphin is always formed, the reaction being expressed by the equation:

$$2C_2H_5I+PH_4I+ZnO=P(C_2H_5)_2H_2I\,.\,ZnI_2+OH_2.$$

The tertiary and quaternary derivatives of phosphonium are not formed in this reaction. These, Hofmann had already shown, might be obtained by the action of the alcohols themselves on phosphonic iodide. The separation of the mono- and di- compounds

is very easy. Water readily decomposes the first, setting the phosphine free, and leaving the latter unchanged in solution. The phosphine may then be separated by distillation, and dried by means of potassic hydrate. From the residue in the retort, the di-compound may be separated by distilling with caustic soda in an atmosphere of hydrogen. Monethyl phosphin, $P(\Theta_2H_5)H_2$, is a colorless, transparent, mobile liquid, lighter than water, boiling at 25° C., without action on vegetable colors, and possessing a truly fearful odor. In contact with chlorine, bromine, iodine, and fuming nitric acid, it takes fire. It unites with sulphur and carbonic disulphide to form fluid compounds. With chlorhydric, bromhydric and iodhydric acids it unites to form salts. The chlorhydrate forms a beautiful carmine-red, crystalline salt with platinic chloride. Diethyl phosphin, $P(\Theta_2H_5)_2H$, is a colorless, transparent, perfectly neutral liquid, insoluble in and lighter than water. It boils at 85° C., and has a penetrating and persistent odor. It oxidizes readily in the air, and sometimes even takes fire; it also unites with sulphur and carbonic disulphide to form fluid compounds. Diethyl phosphin unites with acids to form salts which, with the exception of the iodhydrate, are difficult to crystallize. Methyl phosphine, $P(\Theta_2H_5)H_2$, is a colorless gas, with an odor even worse than that of the ethyl compound. It may be condensed to a liquid by cold or pressure. The salts of this base are decomposed by water. Dimethyl phosphin is a colorless liquid, insoluble in water, and boiling at 25° C. like its isomer ethyl phosphin. It takes fire when exposed to air, and forms very soluble salts with acids.—*Berichte der Deutschen Chem. Gesellschaft, Band* iv, pp. 430 and 605. W. G.

II. Geology and Natural History.

1. *Note on an Apparent Violation of the Law of Regular Progressive debituminisation of the American Coal beds coming East;* by J. P. Lesley. (Proc. Am. Phil. Soc., xii, p. 125, 1871.)—In the course of a Geological survey of certain lands in Somerset county, Pennsylvania, it appeared that the beds of coal existing at Ursina held much less volatile matter than was expected. The gas coals of Westmoreland county, which come east as far as Connellsville, only thirty miles west of Ursina, hold between 30 and 40 per cent. of volatile matters. Three analyses show Ursina coals to have but 17 per cent., while a fourth gives 22 per cent. This puts the Somerset county ooals into the *semi-bituminous* class. Yet the specimens were taken from gangways, a good many years old, and several hundred feet from the outcrop, under high hill cover, at a point on the *western* border of the First Bituminous Coal Basin of Pennsylvania, near the Maryland and Virginia State line. More properly we should say that the Ursina coals lie in the second synclinal of the First Basin. For the Negro Mountain anticlinal comes up from Virginia and splits the First Basin into two in Pennsylvania. The Mountain dies down at Castleman's River; but the anticlinal axis runs on

northward. The First Basin is similarly split into two, east of Johnstown, by the Viaduct anticlinal, which may or may not be an actual prolongation of Negro Mountain.

To make the situation understood, the following extracts from my report to the owners of the property will suffice. The accompanying map shows the Backbone of the Alleghany passing by Altoona. This is the eastern edge of the First Bituminous Coal Basin. The two long parallel mountains between Ursina and Connellsville enclose the Second Bituminous Coal Basin of Pennsylvania. The Third, Fourth and Fifth lie west of it, and the Sixth occupies the northwest corner of the map; no mountains separating the last four. [The map referred to is here omitted].

The property surveyed, in this instance, lies in my old tramping and camping ground of 1840, during the fifth year of the State Geological Survey. The report which Mr. James T. Hodge and myself made to Mr. H. D. Rogers, Chief of the Survey, may be found recorded in the Fifth Annual Report (1841), pages 89-92, which I will here recapitulate in the *descending* order of the beds, for convenience of comparison.

The Pittsburg bed, I, has been eroded from the whole country between the Alleghany Mountain and Chestnut Ridge (at Connellsville and Blairsville) except two hill tops; one near Salisbury, and the other near Ligonier. It is possible also that a third exception may be discovered in the high hill country south of Johnstown, where a conspicuous bench runs along the hill-tops for several miles.

Limestone 20 feet below I, 6 feet thick in the Ligonier Basin.

Coal bed H, 50 feet below I, 3 feet thick in the Ligonier Basin; 1 foot thick in the Salisbury Basin.

Coal bed G, 100 feet below H, 1½ feet thick in the Salisbury Basin; encircles the highest hill-tops in the Ursina Basin with a conspicuous bench. Fort Hill is not quite high enough to have it.

Red Shales between G and F.

Coal bed F, 90 feet below G; generally small; but 4 feet thick in the Salisbury Basin. It forms the high terrace of the Fort Hill.

Mahoning Sandrock.

Coal bed E, "Upper Freeport," 50 feet below F; 2 feet thick, on 2 feet of *Limestone* (over it Shales with *ore-balls*) in Ursina Basin; 3 feet thick, on 5 feet of *Limestone* in the Salisbury Basin.

Coal bed D, "Lower Freeport," 60 feet below E, 6 feet thick in Ursina Basin; 4 feet, farther north; over 10 feet of sandstone with *ore-balls*, in two beds, 7 feet asunder, 11 inches in all. This ore-ball horizon is very extensive north and south of the River.

Coal bed C, 20 feet below D, 2½ to 4 feet thick.

Coal bed B, 30 feet below C on Cox's Creek, 40 on Laurel Hill Creek (N. Fork), and 60 at Confluence; 4 feet thick over 8 feet of *Limestone* on the river; 1½ feet thick over 4 feet of *Limestone* on the North Fork. Twenty feet above B lie 15 feet of Shales, etc., containing *ore-balls*, on Spring Run, below Pinkerton's Bend of the river.

Coal Bed, 22 feet below Limestone, on west bank of Castleman's river, ¼ mile above Zook's Run ford, and on North Fork at old salt boring; carries 5 feet of Shale, containing 1 foot of *ore-balls.*

Coal bed A, 70 feet below B; 22 inches thick, at Shroff's Bridge over Castleman's river.

Conglomerate; 30 feet below A; the interval being massive sandstone.

Such was the general scheme of the Coal measures made out during the old survey, and, however subsequently modified, it has been of incalculable value in all subsequent special and private investigations. It was a very successful attempt to reduce to system the heterogeneous mass of details collected from all parts of the Bituminous Coal Region of western Pennsylvania outside, or to the east, of the Monongahela River Upper Coal Beds, and of the Alleghany River Lower Coal Beds. It was by the collation of these three generalizations, that the first knowledge of the true order of the American Coal Measures was obtained, a starting point and a basis for all the Western Surveys.

[The details with regard to the region and the beds of rock and coal are here omitted]. Analyses of specimens from one of the beds called the Ferriferous Bed afforded as a mean of two analyses:

Volatile matters and water	17·125
Water alone	
Fixed carbon	68·535
Ashes	14·34

A specimen from another opening, near the mouth of Brown's Creek, gave:

Water	0·55
Volatile substances (gas)	21·90
Carbon (coke)	60·98
Sulphur (in ash)	0·62
Ash	15·95

That both the 6-foot and the 3-foot Ursina beds, situated at the western limit of the 1st Bituminous Coal Basin, should have only 17 per cent. of volatile matters,—not more than the coals of the Broad Top Region lying one hundred miles to the east of Ursina —is truly remarkable. The Broad Top beds are tilted and faulted abundantly. The Somerset County beds are almost perfectly undisturbed. The coal in one gangway showed 22 per cent. of volatile substances. But even this is no greater than the coals of the Alleghany Mountains and the coals of the Cumberland Coal Region.

No proper scheme of the *rates of debituminization to easting* and to *disturbance*, can be obtained until all the analyses of each bed in the series of Coal Measures shall be tabulated apart from the rest. We may then expect to learn something also respecting the influence of specific vegetation upon the percentages of coke and gas.

But in the outset one source of error must be guarded against. The specimens of coal, from which the foregoing analyses were made, were obtained in the walls of old gangways. It is possible that they had been long enough exposed to the air to lose some of their hydro-carbons by spontaneous evaporation. The rate at which this goes on in coal mines and exposed heaps is variously stated by those who have investigated the subject.

Dr. Richters made a recent communication to a German Journal, in which he states his opinion that the weathering of coal depends upon its ability to absorb oxygen, converting the hydro-carbons into water and carbonic acid. At a heat, say of 375° F., only 5 or 6 per cent. of the carbon accepts oxygen; the rest seems to show little or no disposition to affine with it. The process is apparently dependent upon the per-centage of hydrogen. But with coal, cold or at ordinary temperature, the oxidation is so slow as to be imperceptible, even after exposure for an entire year. He says moisture has no accelerating effect, unless pyrites is present in quantity. Pure coal, heaped up for nine months or a year, unprotected by the weather and not allowed to become heated, is changed no more than it would be in a perfectly dry place.

Herr Grundmann, of Tarnowitz, on the other hand, has recently published elaborate experiments proving the effects of exposure on bituminous coals to be most serious. Coal which he exposed for nine months lost *fifty per cent.* of its value as fuel. His conclusions excited such doubts, that his experiments were repeated, in connection with Herr Varrentrapp, of Brunswick, who proved by laboratory experiments that oxidation took place at common temperatures. Three months sufficed to rob coal, kept uniformly at 140° C. (284° F.) of *all its carbon*, a heat less than that evolved in coal heaps exposed to the air.

Grundmann proved that the decomposition was the same in the middle of the heap as at the surface, and reached its maximum about the third or fourth week: that half of the oxygen was absorbed during the first fourteen days; that a coal poor in oxygen absorbs it most rapidly; that moisture is an important condition; that coals making, when freshly mined, a firm, coherent coke of good quality, make, after even only *eleven days* exposure, either no coherent coke at all, or coherent coke of quite inferior quality. For gas purposes, also, the coal is greatly injured.

It is evident that these facts have an important bearing on the value of the analyses given above.

2. *On the Oil wells of Terre Haute, Indiana;* by T. Sterry Hunt. Abstract of a paper presented to the American Association for the Advancement of Science, Indianapolis, Aug., 1871.—In previous publications I have endeavored to show that the source of the petroleum in southwest Ontario, and probably in some other localities, is to be sought in the oleiferous limestones of the Corniferous and Niagara formations, both of which abound in indigenous petroleum. I have, however, expressed the opinion that the overlying sandstones in Pennsylvania are also truly oleiferous.

In a paper read to this Association last year, I showed that the Niagara limestone at Chicago holds imprisoned in its pores an enormous quantity of oil, and remarked that the reservoirs which supply the wells in other districts are fissures along anticlinals, which, though sometimes occurring in strata above the oil bearing horizon in Ontario, frequently occur in the Corniferous limestone itself. Hence the view held by some that the source of the oil in that region is to be sought in the overlying strata is negatived.

In Ontario there intervenes between the Corniferous and Niagara formations, the great saliferous series known as Onondaga or Salina formation. This, however, is wanting to the westward, where the first two formations come together, and according to Professor Cox, where exposed at North Vernon, Indiana, are both oleiferous.

A well lately sunk at Terre Haute, Indiana, in search of fresh water, has shown the existence of a productive source of oil in that region. It was carried 1,900 feet, and yields about two barrels of oil daily. A second well, a quarter of a mile east of north from the first, has given a supply of twenty-five barrels of oil daily. After passing through 150 feet of superficial sand and gravel, the boring was carried to a depth of 1,625 feet, where the oil was struck.

According to Prof. Cox, the strata passed through are as follows: Coal measures 700 feet; Carboniferous limestone, with underlying sandstone and shales, 700 feet; black pyroschists, regarded as equivalent of the Genesee slates, 50 feet. Beneath this, at a depth of twenty-five feet, in the underlying Corniferous limestone, the oil vein was met with.

The oil in the first well was found at the same horizon. A third well, about a mile to the eastward, was carried to a depth of 2,000 feet, but no traces of oil were met with.

This locality, on the Wabash river, is, according to Prof. Cox, on the line of a gentle anticlinal or uplift which is traced a long distance to the west of south. The relation of productive oil wells to such anticlinals was pointed out by Prof. Andrews and by myself in 1861.

Postscriptum.—In a note in this Journal for September (page 215), Mr. A. D. Warner refers to a paper by me on *The Oil-bearing Limestone of Chicago*, which appeared in this Journal for June (p. 420), and quotes from me as saying therein that "much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigenous to certain sandstones in the Devonian and Carboniferous rocks." It would have given a more correct idea of my views, had he cited the words preceding; after maintaining that a principal source of the petroleum is in lower rocks, in fact the limestone of the Niagara and Corniferous formations, I added: "There is however, reason to believe, as I have elsewhere pointed out, that much of the petroleum, etc." I there referred to the Geology of Canada, 1863-66, page 24, where I cite from two papers of J. P. Lesley (Amer. Phil. Society, x, 33, 187), and it is from the evidence there given by him, and not upon my own observations,

that I conclude "we have reason to believe" in the existence of indigenous petroleum in the sandstones in question. Lesley there states that the oil in these rocks occurs in thin fissures corresponding to the remains of plant stems which have disappeared, having been converted into petroleum, an observation which is an answer to Mr. Warner's remark that while the sand-rocks in question are seen in certain parts to abound in fossil plants, " they contain nothing from which the petroleum could possibly have been derived". While I have constantly maintained the view held by Mr. Warner, that the oil, so far as I have studied it, comes from a lower horizon, I am nevertheless not disposed to reject the statements of so skilled an observer as Mr. Lesley. Mr. Warner will find in the facts ascertained at Terre Haute a confirmation of the view that the petroleum in this region, at least, comes not from the sandstone, nor even from the underlying pyroschists, but from the still lower limestones of the Niagara and Corniferous formations.

Montreal, Sept. 8, 1871.

3. *Surface Geology of New Brunswick;* by G. F. MATTHEW, Esq., (Proc. Nat. Hist. Soc. of New Brunswick, April, 1871.)—The author closes his paper with the following conclusions.

1st. The present summer climate of a large part of Acadia is such as to compare with that of the region around Lake Superior, where according to Prof. L. Agassiz and Sir W. E. Logan, glaciers existed during the Drift period. The resemblance in the climatic conditions of the two regions is shown both by their mean summer temperatures and by the distribution of indigenous plants. (See Can. Nat., June, 1869.) The authority of Messrs. L. Agassiz and J. D. Dana may be quoted in favor of the former existence of glaciers in southern New England, which enjoys a summer temperature considerably higher than Acadia.

2nd. Some of the phenomena of the drift epoch, such as the direction and position of the glacial striæ and the distribution of the clays, do not appear susceptible of explanation on the hypothesis that icebergs and ocean-currents alone produced them. And it seems reasonable to suppose that a great sheet of ice similar to the continental glaciers of Greenland and the Antarctic regions, which will explain these phenomena, covered the Lower Provinces during the glacial epoch; and that while the general course of this mass was southward toward the then existing ocean, the motion of the deeply-buried ice in the bottom of the glacier was partly governed by the configuration of the land beneath it.

3rd. That while the western portion of this icy mass was steadily moving down the Atlantic slope from the table land of northern Maine, and the eastern pushing across the low swell of land which separates the Gulf of St. Lawrence from the Bay of Fundy, the motion of the central portion of the ice-sheet, which could have had but a slight inclination, would have been impeded or nearly arrested by the southern hills of New Brunswick.

4th. That such portions of the glacier as were pushed over the tops of these hills, or through the narrow valleys between them, conformed in some degree to the slope of the surfaces over which they moved.

5th. The erosion effected by the glacier was chiefly in the softer rocks of the country; the harder ones resisting the attritive power of the ice, and preserving with comparatively little change their pre-glacial outline.

4. *Remarks on Fossil Vertebrates from Wyoming.* (Proc. Acad. Nat. Sci. Philad., August 8, 1871.)—Prof. Leidy remarked that the collections of fossils presented this evening by Drs. J. Van A. Carter and Joseph K. Corsos were of unusual interest. They consist of remains mainly of turtles, with those of mammals and crocodiles, and were obtained from the tertiary deposits in the vicinity of Fort Bridger, Wyoming Territory.

The great abundance of remains of turtles, of many species and genera, of fresh-water and terrestrial habit, obtained in Wyoming, indicates this region to have swarmed with these animals during the earlier portion of the Tertiary period. Crocodiles and lacertian reptiles were likewise numerous. The many mammalian remains found in association with the reptilian fossils mainly belong to tapiroid and carnivorous animals.

The Wyoming tertiary fauna presents a remarkable contrast with the later faunæ of the Mauvaises Terres of White River, Dacota, and of the Niobrara River, Nebraska. Among the large number of fossils from these two localities, rich in evidence of mammalian life, there occur the remains of a single species of turtle in each, and none of crocodiles or other reptiles.

Dr. Carter's collection, besides containing remains of *Trionyx guttatus*, *Emys Jeanesianus*, *E. Haydeni*, and *E. Stevensonianus*, and *Baena arenosa*, also adds two new turtles to the list. One of these is a species of Emys of the largest size, and exceeds any now living. The carapace has measured about two feet and a half in length, and the sternum about two feet. In honor of its discoverer, it may be named *Emys Carteri.*

The first and second vertebral plates of this species present an unusual, perhaps an anomalous appearance. The first is 4 inches long, and clavate in shape, with the narrow part foremost. The second is 2¼ inches long, and presents the usual hexagonal form reversed. The third plate, a little longer, is quadrate, with convex sides. The first vertebral scute is vase-like in outline, 5½ inches long, 2¾ inches wide in front, 4¾ inches near the middle, and 3¼ inches at the back border. The second scute, of the ordinary form, is 5 inches long, and 4 inches wide.

The second turtle belongs to the recently characterized genus *Baena*, but is considerably larger than its associated species which have been described. The shell in its complete condition has been upwards of a foot and a half in length, and is seven inches and a half high. The sternum is flat, and about fifteen inches long. Its pedicles ascend at an angle of about 45°, and

are seven inches and a half broad. As in the living *Dermatemys*, and the sea turtles, they are covered with large scutes, four in number, as in *Baena arenosa.* The intermediate vertebral scutes are longer than broad—the third being 4 inches long, and 3½ inches wide. A peculiarity of the species is the undulating manner in which the costal scutes join the marginal scutes, and the sternal scutes one another. The species may be named *Baena undata.*

Dr. Carter's collection also contains some fragments of bones of a large mammal, which are so mutilated as to be hardly characteristic. A jaw fragment among them, with the retained fragments of the true molars, would appear to indicate a species of *Palæosyops* much larger than *P. paludosus.* In absence of other evidence, it might be viewed as a species of this genus, under the name of *P. major.* The true molars occupied a space of four and a half inches. The last molar measured an inch and seven-eighths fore and aft, and an inch transversely in front.

Dr. Carter had also sent some fossils to Prof. Leidy, among which were portions of jaw, with nearly full series teeth of *Hyrachyus agrarius.* This animal is related to the Tapir, *Hyracodon*, and *Lophiodon.* The formula of its dentition is the same as in *Hyracodon:* 7 molars, 1 canine, and 3 incisors. The true molars are like those of *Lophiodon*, except that the last lower one has a bi-lobed instead of a triple-lobed crown. Apparently the same animal has been indicated by Prof. Marsh under the name of *Lophiodon Bairdianus.* A fragment of a lower jaw containing the last premolar, and the first true molar, indicates a larger species of *Hyrachyus*, which may be named *H. eximius.* The crown of the last premolar is 7¼ lines antero-posteriorly, and 5½ transversely. The true molar has measured about 8½ lines fore and aft, and 6 lines transversely. The depth of the jaw fragment below the true molar is over an inch and a half.

Another fossil is a mutilated incisor, indicating a species of *Trogosus* rather more than half the size of *T. castoridens*, which may be named *T. vetulus.*

A femur of *Palæosyops paludosus*, in the collection, exhibits the third trochanter, characteristic of the unequal-toed pachyderms. The astragalus of this animal almost repeats that of the living Tapirs.

Among the remains of Dr. Corson's collection there is the greater part of the lower jaw of a large crocodile, but too much broken to attempt to give an opinion in regard to its specific character, until it is in some degree mended or restored.

5. *Dredging in Lake Superior under the direction of the U. S. Lake Survey.*—Extensive dredgings were undertaken the past season in Lake Superior, from the U. S. steamer Search, under the direction of Gen. C. B. Comstock, Superintendent of the Lake Survey. Dredging was carried on from the shallow waters, especially along the north shore, down to 169 fathoms, the deepest point known in the lake. In all the deeper parts of the lake, the bottom, as shown both by the dredging and by the soundings

executed by the Survey, is covered with a uniform deposit of clay, or clayey mud, usually very soft and bluish or drab in color. Water brought from the bottom at many points was perfectly fresh; that from 169 fathoms gave no precipitate with nitrate of silver. The temperature, everywhere below 30 or 40 fathoms, varied very little from 39°, while at surface (at the time of the observations, during August) it varied from 50° to 55°. The fauna of the bottom corresponds with these physical conditions. In the shallow waters, the species vary with the varying character of the bottom, while below 30 to 40 fathoms, where the deep-water fauna properly begins, the species seem to be everywhere very uniformly distributed. The deep-water fauna, as might be expected from the unfavorable character of the bottom, is meager, and seems to be characterized rather by the absence of many of the shore species than by forms peculiar to itself. Some of the more interesting species occurring in deep water were: *Mysis relicta* Lovén, at various depths from 4 to 159 fathoms; *Pontoporeia affinis* Lindst., at nearly every haul from the shallowest to the deepest; a small undescribed species of *Pisidium*, down to 159 fathoms; several forms of dipterous larvæ, allied to *Chironomus*, down to the same depth; several species of Lumbricoid worms, of the genera *Tubifex*, *Sænuris*, and an allied genns; and a species of *Hydra*, which was found from the shore down to 159 fathoms. Of these, the *Mysis*, *Pontoporeia*, and *Pisidium* are identical with species found by Dr. Stimpson in his dredging in Lake Michigan, a short account of which was published in the American Naturalist for September, 1870. The species of *Mysis* and *Pontoporeia* I am unable to distinguish from specimens from Lake Wetter in Sweden. In the Swedish lakes, these species were associated with *Idotæa entomon* and *Gammaracanthus loricatus*, marine species, and were supposed by Lovén to have been derived from ancient marine species left in the lake basins by the recession of the ocean. The occurrence of these forms in Lake Superior, so far removed from the ocean, is certainly a very interesting fact in the geographical distribution of species, but one which I will not attempt to discuss in this brief notice. In the shallow waters many interesting species were obtained. Among these was a new species of *Crangonyx*, a genus closely allied to *Gammarus*, and heretofore known only from a few species found in the fresh waters of the old world, which occurred in 8 to 13 fathoms; and at the same depth, species of *Lumbricus*, *Nephelis*, *Procotyla*, *Gammarus*, *Asellus*, *Limnæa*, *Physa*, *Planorbis*, *Valvata*, *Sphærium*, *Pisidium*, etc. A full report will soon be published. S. I. SMITH.

6. *A. Featherman: Report of Botanical Survey of Southern and Central Louisiana.* In the *Annual Report of the Board of Supervisors of Louisiana State University, for year* 1870. New Orleans, 1871.—The Botanical Report, separately paged, fills 130 pages. Professor Featherman is Lecturer on Botany in the Uni-

versity, and Professor of Modern Languages. The general matter, which makes the principal staple of this Report, is of considerable interest, although the information afforded is in some cases decidedly trite. Our attention is concentrated upon the list of new species, twelve in number, which we enumerate, appending the names which they have previously received, some of them in works which Prof. Featherman has probably not had access to. We are indebted to the author for original specimens of some species and drawings of others, without which these determinations could hardly have been made. Taking the species in order:

Euphorbia Ludoviciana is *Phyllanthus Carolinensis* Walt.

E. Meganæsos is *E. maculata* L., a pretty well-marked, more erect, and smoothish variety, of our southern coast.

Sabbatia nana is *S. gracilis* Pursh, a dwarf form, approaching *S. stellaris*.

S. oligophylla is a slender state of *S. gentianoides* Ell.

Hydrolea leptocaulis is *H. affinis* Gray, Manual, ed. 5.

H. Ludoviciana is *H. ovata* Nutt.

Jussiæa Boydiana is *J. repens* L., a small form.

Tephrosia angustifolia, from the drawing is probably only a slender form of the next.

T. multiflora is *T. onobrychoides* Nutt.

Lilium Lockettii is *Crinum Americanum* L.

Œnothera paludosa, for lack of specimen and drawing, is not made out.

Helenium Seminariense is *H. nudiflorum* Nutt., that is, *Leptopoda brachypoda* Torr. and Gray. A. G.

7. *Dr. Rohrbach on Typha.*—Dr. Rohrbach, the monographer of *Silene*, of Berlin, has published a careful revision of the genus *Typha*. He recognizes 9 species, with 4 sub-species: 7 of the former are found in Europe, and 2 of these also in the territories of the United States, together with a sub-species, peculiar to the warmer parts of America.

Dr. R. has discovered that the fruits of 7 of the 9 species show a longitudinal groove, and burst open, emitting the seed, when placed in water: the two others possess no groove, nor do they open, the pericarp being adnate to the seed. Our species belong to the first section.*

The other characters on which he relies to distinguish the species are (1) the shape of the stigma, which is linear, spatulate or rhomboid; (2) the presence or absence of bracts (variable in shape in the same species) at the base of the female flower; (3) the proportional length of the stigmas, the perigonial hairs, and the just mentioned bracts, at the period of maturity of fruit; (4) the presence or absence of hair on the axis of the male inflorescence; (5) the pollen, whether in single grains or in 4 grains united; (6) the anatomical structure of the seed coats.

* The species with adnate pericarp are *T. Laxmanni* Lepechin (the earlier name for *T. minor* Sm.), throughout middle and southern Europe and Asia; and *T. stenophylla* F. & M., extending from Asia into Italy.

The shape of the leaves, and the contiguity or distance of the male and female inflorescence, do not furnish very reliable diagnostics.

Typha latifolia Lin., throughout the United States to the Pacific, and into Mexico. Axis of male inflorescence hairy; pollen grains in 4's; female flowers without bracts; stigma lanceolate-spatulate, much longer than the perigonial hairs; leaves flattish.

Typha angustifolia Lin., in the northern parts of the United States, southward only known in Louisiana. Axis of male inflorescence hairy; hairs linear; pollen grains single; female flowers subtended by bracts, which are of equal length with the perigonial hairs, and much shorter than the linear stigma; leaves convex on back.

Typha Domingensis Pers., from Texas, through the West Indies, and southward (not in the Old World), is a sub-species of the latter. Hair of the male inflorescence tapelike, broader upward; perigonial hair of female flowers slightly clavate (not seen in any other typha); seed coat a little different from that of *T. angustifolia;* leaves almost flat. *T. Teuxillensis* and *T. Tenuifolia* H. B. K., belong here.

A plate elucidates the differences of structure of the seed coats. An alphabetical index enumerates the names and synonyms, and refers them to their proper places. G. E.

III. Astronomy.

1. *Cordoba Observatory.*—The following are extracts from the recent official Report of the Director, Dr. B. A. Gould.

The Observatory is situated on a height or barranca, lying to the southeast of the city of Cordoba, at a distance of eight squares from the principal Plaza, and not far from the gardens of the National Exposition.

The ground plan of the edifice consists of a square, divided into four rooms of $5{\cdot}8^{m}$ a side each; and forming wings to the E. and W. two more rooms of $3{\cdot}6^{m}$ wide by $4{\cdot}2^{m}$ long, destined for observations in the plane of the meridian; and, at the respective extremities of these, two circular towers 6^{m}. in diameter each; while in the north and south direction two smaller towers of 4 meters in diameter serve as prolongations to the edifice. These towers have revolving cupolas, and the whole of the edifice forms a cross terminated at its four extremities by as many towers. Its entire length is about 38^{m} in the direction E. to W., by a width of $24{\cdot}3^{m}$ from N. to S. The height of the larger towers is 6^{m} and that of the small ones only $5{\cdot}4^{m}$.

Your Excellency knows that the materials for the rooms which lie toward the E. and for the towers to the N. S. & E. were sent from the United States in June of the last year, with the exception of the masonry, which it was necessary to have constructed upon the spot. These materials, forming thus two-thirds of the edifice, were received in Cordoba in the 3d week in October, and this part of the edifice at this day, if not completely finished, is, at

least, in a state to be used. The remaining part, my friends in the United States, desirous to contribute to the good success and prompt realization of our establishment, have undertaken to contribute, and only thus has it been possible that these materials should be shipped in the first vessel which sailed this year from the United States for Rio de la Plata. I am notified that these were landed April 1st at Buenos Ayres; nevertheless the public calamity which has weighed upon that city and the restrictions which have, in consequence, been imposed on trade in other parts of the republic, have thus far delayed the reception of this last part of the edifice. When they reach us their putting together will be the work of a few weeks, thus completing the Observatory.

It would not be possible for me to recount here the efficient aid which your institution has received from its commencement as well from the authorities of the Province as from the citizens of Cordoba. The latter authorized me on my arrival to choose a lot of land of adequate size wherever it might be considered most convenient, and have since conveyed a square lot of $216{\cdot}9^{m}$ a side.

Our principal instruments, besides clocks, chronometers, chronographs and meteorological apparatus, are the meridian circle, the great equatorial, the small equatorial and the photometer. All these are now in the country; nevertheless we have not been able to avail ourselves of any one of them. Without an embargo, one month more will suffice in my judgment for their collocation.

Our meridian circle was made by Messrs. Repsold & Son of Hamburg, whose workshops are indisputably the most reliable for instruments of this class. The length of the telescope is $1{\cdot}484^{m}$; the aperture of its objective 122^{mm} and the divisions of the circles permit the appreciation of a single second by means of the microscopes. The whole apparatus is mounted on two pillars of white marble from the Sierra of Cordoba, which are laid in solid masonry cement, and are $1{\cdot}61^{m}$ high by $0{\cdot}71^{m}$ wide. Though not the greatest nor the most costly of our apparatus, nor indeed of the greatest magnifying power it is the principal instrument in a certain sense, since with it will have to be executed the greater part of our labors in the next 2 or 3 years. The great Equatorial is the principal instrument, if we take into consideration its imposing size and its magnifying power. Not having ordered it early enough, we had not supposed that it would be finished within the brief time at our disposal, yet I have had the fortune to be able to procure an objective of great excellence, the work of Fitz, a distinguished optician of New York. Its power has been tried by the astronomer Rutherfurd. The celebrated mechanicians, Clark & Sons, have undertaken to mount it, which they have effected with the most complete success. The telescope has an aperture of 28^{cm}, a focal distance of about $3^{m}{\cdot}63$, and is provided with clockwork. It stands upon a pillar of white marble of a height of $1{\cdot}91^{m}$, under the revolving dome of the east tower. The small Equatorial has an aperture of about 13^{cm}, and is provided with two circles minutely divided, but it is without the clockwork apparatus. It also was made by Clark & Son, and is to be placed in the south tower.

In the north tower will be placed the photometer. This small, yet most beautiful, instrument is the work of Ausfeld of Gotha, in Germany, who constructed it under the immediate supervision of the inventor himself, Professor Zoellner of Leipsic. This instrument, as well as the spectroscope constructed for our observatory by Tauber of Leipsic, and which we have not yet received, is the property of the American Academy of Arts and Sciences of Boston, which has entrusted me with the sum of $500 to procure the necessary apparatus for the study of the light of the southern stars, with directions to turn over to them the apparatus acquired with this sum, or a similar amount, as may appear to be most convenient. I do not disguise the confidence which I cherish, that these instruments may be retained as the property of the National Observatory, in view of their rare beauty and excellence.

At a former time I brought it to the knowledge of your Excellency, that the great delay in the placing of the instruments and finishing the building induced me to form a plan of investigations which at the same time that it should bring into action the "personnel" of the Observatory might also conduce to useful and effective results, even without the aid of the large instruments. I informed you of the course adopted in this respect. Without loss of time there was commenced a detailed and laborious series of observations with the naked eye with the object of forming a catalogue of all the stars thus visible in the Southern heavens, according to position and degree of brilliancy and to construct thus a system of maps which shall represent the aspect of the heavens in these latitudes. Such maps do not now exist, nor have there been many accurate determinations of the quantity of light of the stars situated to the south of the Celestial Equator. My object is to supply this want, and the results so far obtained have so far exceeded my expectations that I seriously doubt if we could have done more for the progress of the science if instruments had been at our service. As far as I can estimate, two-thirds, at least, of the labor of observation and computation which this work demands is concluded—thanks to the intense application of my assistants, whose devotion in this regard is no less honorable to themselves than useful to the new institution. I hope that this work will be concluded and given to the press before the end of the current year. The results will appear in a series of charts of the heavens, as they present themselves to the naked eye, and which will comprehend the entire firmament from 10° north of the Equator to the south pole, and will be accompanied by a catalogue of the stars, arranged by constellations, which shall indicate the position and brilliancy of each one of them. This work, the first fruit of the new institution, will bear the name of "Argentine Uranometry," and no exertion on my part shall be omitted that its publication may be a stamp of honor to the nation, which with so much zeal and enlightenment is taking its first steps in the path of a higher civilization.

I have found the heavens of Cordoba less serene and more subject to clouds than I had hoped according to the received data,

nevertheless when they are clear they are of an admirable transparency, as your Excellency may appreciate from the fact that we have observed and reduced to the maps about 4500 stars between the 10th degree of north declination and the south pole, while the Uranometry of Argelander, which contains all the stars visible without instruments between the north pole and 30° of south latitude, contains only 3256 stars. If the Government decides upon the publication of these results, as I cannot doubt will be the case, I am of opinion that the new process of photolithography will supply the most economical and accurate method of executing the maps—this consisting in engraving on stone by means of photographic reagents the maps drawn on a larger scale.

I trust that the completion of the *Uranometry* will occupy us only a few months more, though naturally it may be somewhat retarded by the distraction of our forces in using the instruments which are soon to come into activity. Immediately upon concluding the slow and detailed observations which the collocation of the instruments demand, I propose to commence a systematic study of the southern hemisphere, beginning at the limit to which northern astronomers have advanced. The very valuable observations taken at Cape Town, at Madras, Melbourne and Santiago will serve for a beginning to this labor, which is designed rather for the formation of a complete catalogue of all the stars within a certain limit of brilliancy, than for the attainment of the greatest possible precision in the determination of the positions of a smaller number. This work proceeds by the observation of "zones" of stars, which are intended to embrace all of a certain brilliancy, situated in a given region of the heavens. The same proceeding is successively repeated up to the definitive exploration of the entire space between the proposed limits. A similar examination has been made by the German astronomers, Bessel and Argelander, in all the heavens to the north of the 30th degree of south declination; and by the American astronomer, Gilliss, in Santiago, in Chili, in the region extending from 23°, more or less, to the vicinity of the South Pole. Though these last mentioned observations have not been published, yet they are at this moment in preparation for the press on account of the Government of the United States. If the Argentine National Observatory could coöperate by filling up the space between the two series of zones above-mentioned, so as to form a continuous whole, the scientific world would appreciate the work, and offer its tribute of gratitude through long years to come.

The National Congress has without solicitation from Dr. Gould provided for an observer's dwelling upon the Observatory grounds.

The report goes on to suggest two ways by which the Observatory can be of especial use in developing the science of the country—1st, by the telegraphic determination of longitudes; and 2d, by the formation of a system of meteorological observations throughout the Republic.

President Sarmiento and the Minister of Public Instruction have officially approved the report, and promise to put the institution into relations with the national establishments of public instruction, in order to carry on a full system of meteorological observations.

2. *Encke's Comet.*—A view of Encke's comet was obtained at the Observatory of the Sheffield Scientific School on the evening of Oct. 13th. It was barely visible as a diffuse nebula. The following places of the comet, taken from an ephemeris by S. von Glasenapp of Pulkowa, and published in No. 1854 of the *Astronomische Nachrichten*, may be of interest to observers.

0^h Berl. m. t.		A.R.			Decl.			log. dist. to ☉	log. △	$\frac{a^2(a-1)^2}{r^2\Delta^2}$
		h	m	s	°	′	″			
Aug.	18	2	8	35·83	+23	32	33·1	0·33419	0·21013	0·58
Sept.	20	2	0	14·85	30	36	41·3	0·25522	9·97354	2·37
Oct.	21	0	21	52·73	38	54	38·5	0·14690	9·66369	17·10
	29	23	18	44·39	38	54	48·4	0·10987	9·58273	29·47
Nov.	2	22	40	41·93	37	39	10·8	0·08931	9·54811	37·06
	6	22	0	21·40	35	16	23·6	0·06716	9·52021	47·80
	10	21	19	56·91	31	44	32·8	0·04317	9·50100	58·33
	14	20	41	26·49	27	14	9·9	0·01707	9·49178	68·63
	18	20	5	57·91	22	4	26·7	9·98850	9·49254	77·96
	22	19	33	47·49	16	36	17·1	9·95703	9·50334	85·84
	26	19	4	38·22	11	6	31·3	9·92215	9·52258	92·19
	30	18	38	3·47	5	46	7·2	9·88322	9·54957	97·43
Dec.	4	18	13	41·66	+ 0	41	12·7	9·83947	9·58379	101·81
	16	17	15	19·72	−12	37	13·7	9·67272	9·72983	111·99

After reaching the perihelion December 29th, the comet will be too near the sun to be easily observed. In 1829 the comet was first seen with a light-intensity of 1·2. In 1868 it was first seen with a light of 2·2. On the night of Oct. 13th the light was about 10, according to von Glasenapp's ephemeris.

3. *Discovery of new Planet.*—Dr. LUTHER of Bilk discovered a new planet (117) on the 14th of Sept. It was equal in brilliancy to a star of the 11th magnitude.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Midway Islands, in the North Pacific.*—It is well known that the Hawaian line of islands is continued beyond Kauai in a series of coral islands or atolls, which, together with the high islands from Kauai to Hawaii, make the whole length of the Hawaian chain full 2000 miles. Some of these islands were surveyed by the U. S. Government in 1867, with reference to harbors and a place of depot for coal, to serve as a half-way station, for the North Pacific line of steamers. We take the following facts respecting the three islands particulary surveyed, from the Report to the Bureau of Navigation, in December, 1867, of Capt. Wm. Reynolds, U. S. N. These three islands are Ocean Island in latitude 28° 25′ N. and longitude 178° 25′ W; Midway or Brooks Island, in 28° 15′ N. and 177° 20′ W.; and Pearl and Hermes Island in 27° 50′ N. and 175° 50′ W.

In Brooks Island, which was the best of the three as regards harbor, the encircling reef is 18 miles in circumference. On the west-north-west side, for three miles, the reef is mostly wanting, and there are 3 to 10 fathoms water. At the northwest point there are breakers; and then from there, along by the east side, for 4¼ miles, there is a steep wall of compact coral rock, of about 5 feet elevation, and only 6 to 20 feet wide, where examined; beyond this, the wall becomes a line of detached rocks, and for 2 miles is hardly above tide level, and then for another 2 miles under water, except at low tide; but for the next 4½ miles, along the southern and southwestern sides, there is again a continuous wall for 4½ miles. There is no vegetation along the wall. Whether this wall indicates an elevation of the island or not, it is difficult to say. It is more probable that there has been a subsidence of four or five feet, and that the wall is only the ruins of the coral rock that formed the dry land of an atoll once in much better condition.

The only harbor entrance is on the west or leeward side. The harbor—called Welles Harbor—is rather larger than that of Honolulu (of Oahu), and as safe, but has not quite as much water on the bar—the depth being from 21 to 16 feet at low water. The entrance between the reefs is 800 feet. On the southwest reef there is a small island, called Middle Brooks Island, whose highest point is 15 feet above the sea; its vegetation is shrubs and grasses. The lagoon is 2 miles long and 1½ miles in its greatest width. There are many clumps of coral with 1 to 2 fathoms over them; but the rest of the bottom is of white coral sand.

Turtle abound on the island, but seals were seen only occasionally. Birds were very numerous, and the young birds were so many as to make it difficult to walk any distance without trampling on them. There is but little guano, and this is probably owing to the condition of the reef.

Ocean Island is much like Brooks, in having a wall of coral rock on its northwest, north and east sides; the north side reef is at low tide level. There is no ship entrance to the lagoon. There is a green islet at the southeast corner like that of Brooks Island, its height above the sea 10 feet. The reef has a circuit of 14¾ miles.

Pearl and Hermes reef closely resembles the other two, but the wall is rather a line of detached rocks than a continuous parapet. The circumference of the reef is 42 miles, the length from east to west being 16 miles, and that from north to south 16 miles.

2. *Eruption of the Volcano of Colima in June,* 1869;* by Dr. Charles Sartorius.—To the northwest of the town of Colima rise, above lower mountains, two lofty volcanic peaks, the more easterly, capped with snow, being 3,790 metres (12,434 feet) in height, the more westerly, with a conspicuous crater, 3,580 metres (11,745 feet). The latter had an eruption in the year 1818, but has since remained in repose, though thin clouds of smoke have often ascended from its summit.

On the 12th June, 1869, a dense smoke issued from the crater, and at night a bright light was visible at its mouth; detonations

* Smithsonian Report, 1869, p. 423.

like the discharge of distant artillery were heard, but no concussion of the earth took place. On the 13th there was observed from the hacienda (farm) of San Marcos, four leagues distant from the volcano, on its northeast side, at the foot of the steep cone, a glowing heaving (*Anschwellung*) of the surface, which continued to increase, and displayed intensely luminous clefts, from which were ejected smoke and red-hot stones, extending in the direction of the snowy peak above mentioned.

The civil engineer, Ricardo Orosco, ascended the volcano on the 15th of June, accompanied by two servants and a guide. At 6 o'clock in the morning he left San Marcos, and reached at 12 o'clock a plain at the foot of the steep cone, where he left the horses. A heavy storm was prevailing, the temperature of the air being 10° Réaumur, (55° F.) On a second small plain, upon the northeast side of the mountain, was the new upheaval, which ascended to the scarp of the cone and stretched in the direction of the snowy peak, the latter being 4,500 metres ($2\frac{4}{5}$ miles) distant. The upheaval in question seemed to be some 35 metres (114 feet) high and 230 metres (754 feet) broad, forming a flattened arch. The appearance was that of a wild mass of volcanic, red-hot rocks heaped one upon another and constantly in motion, not unlike freshly-burnt lime when sprinkled with water. The rocks which rolled down were, on cooling, of a gray color. A piece broken off rang like glass, and was vitreous and porous. In the middle of the upheaved mass the movement was strongest; there large clefts and intense light were displayed, while engulfed stones, which were swallowed up in great masses, were followed by a noise as of violent wind and by clouds of smoke, sometimes blue, sometimes yellow. The temperature of the air in the vicinity was 42° R., (126° F.) The stones in the midst of the heaving mass seemed to be softened, though not melted, and no flow of lava took place. Orosco ascended the cone in order to observe the phenomenon from above. This cone is very steep, and consists of sand and volcanic rubble. The temperature on the summit, which was reached at 2 o'clock p. m., was found to be 4° R., (41° F.) From hence the whole of the new upheaval could be surveyed. In the middle of it the most vehement movement was in progress, attended by the constant upheaving and descent of rocky masses, fire, and blue and yellow columns of smoke.

The upper (ancient) crater has a diameter of 150 metres (492 feet), descends in a cone-like form, and shows around its circumference many fissures and rifts. From the center and walls arose a dense sulphurous vapor. The gases from the new theater of eruption had a smell like that of burning stone-coal.

The descent was very toilsome on account of the rolling stones. At 3.30 p. m. the horses were reached, and at 9.30 the hacienda of San Marcos, where many were waiting to learn the result of the expedition. The report of Orosco was, that the district was threatened with no danger, as no lava was issuing, and the fissures being open gave no reason to fear any explosion from the tension of confined vapors. Later explorers of the volcano found a fissure

from the new upheaval to the upper peak, one to three feet wide and about three feet in depth, but neither heat nor vapor issuing from it. The latest reports inform us that the same phenomena in general continue to present themselves, but that such volumes of fetid gases issue from the fissure, that the inhabitants of the district were forced to leave their abodes. Cows and sheep were killed thereby, so that it was found necessary to drive away the herds from the neighborhood of the volcano.

3. *The Variations of Gravity in the Western Provinces of Russia;* by A. SAWITSCH. (Abstract, M. N. Roy. Astron. Soc., June 9.)—A great arc of the meridian having been measured in Russia with all the precision which modern methods of observation will admit of, it became an interesting subject to examine the variations of the intensity of gravity in the districts traversed by this arc, and to compare the progress of those changes with the variations which are observed in the direction of gravity determined at several stations by astronomical observations and geodetical operations. An extensive series of pendulum observations was therefore arranged by the Academy of Sciences of St. Petersburg, to be made at certain stations between Tornea in Finland, and Ismail in Moldavia, selecting only those points of which the geographical positions and elevations above the mean level of the sea were determined in connection with the great arc of meridian. The observations between Tornea and St. Petersburg were made during the summer of 1865 by M. Sawitsch and M. Lenz; those between St. Petersburg and Ismail were made in 1866 and 1868 by M. Sawitsch and M. Smyslof.

M. Sawitsch gives in detail the formulæ used by him in the reductions, and also the results of the observations, which are given for twelve different stations situated between 65° 51′ and 45° 20′ north latitude. At St. Petersburg the length of the seconds' pendulum found directly from the observations is 440·958 Paris lines, the latitude being 59° 56′ 30″.

"Our object was not so much to determine the absolute length of the pendulum as to collect new data on the variations of gravity, and to compare them with those which have been found at other stations on the terrestrial surface. We know that at London the length of the simple seconds' pendulum has been determined with great precision by Capt. Kater and by General Sir E. Sabine; and that the measures made in Great Britain by M. Biot agree perfectly with those obtained by the English savants, while those made in France by the English savants give the same results as those of M. Biot. To these determinations we may also add the observations made by travelers and naval officers in different parts of the world. To connect our experiments with the preceding system of researches, without a breaking of continuity, we prefer not to adopt our direct determination of the length of the pendulum at St. Petersburg, but rather that which was deduced from the oscillations of a similar invariable pendulum, observed by M. le Comte Luetke at St. Petersburg and at the Royal Observatory at Greenwich; the difference between the length of the

seconds' pendulum at Greenwich and London having been accurately determined by Sir E. Sabine. Thus the length of the simple seconds' pendulum being known at London, we can calculate its length at St. Petersburg according to the relation of the squares of the numbers of infinitely small oscillations which the comparison pendulum, reduced to the same temperature *in vacuo*, has made at each of the stations in a mean day. In this manner, the calculation gives for the length of the simple seconds' pendulum at St. Petersburg 39·16975 English inches or 441·0319 Paris lines. Assuming this length, we have deduced, as the result of our observations, the values contained in the first three columns of the following table.

Place of observation.	Latitude N. ° ′ ″	Longitude E. from Greenwich. h m s	Length of the Seconds pendulum in Paris lines.	Errors. Paris lines.
Tornea,	65 50 43	1 36 54	441·2525	+0·0200
Nicolaistadt,	63 5 33	1 26 26	441·1293	−0·0141
St. Petersburg,	59 56 30	2 1 14	441·0319	−0·0017
Réval,	59 26 37	1 39 1	441·0190	+0·0033
Dorpat,	58 22 47	1 46 54	440·9762	−0·0002
Jacobstadt,	56 30 3	1 43 4	440·8900	−0·0157
Wilna,	54 41 2	1 41 12	440·8353	−0·0001
Bélin,	52 2 22	1 40 52	440·7268	−0·0035
Króménetz,	50 6 8	1 42 54	440·6533	+0·0017
Kaménetz-Podolsk,	48 4 39	1 46 18	440·5844	+0·0160
Kischinef,	47 1 30	1 55 18	440·5278	+0·0030
Ismail,	45 20 34	1 55 16	440·4479	−0·0071

To examine the accuracy of each of the results M. Sawitsch has compared the length of the pendulum observed at each station, with the corresponding length obtained from the formulæ given in his paper. The residuals are as given in the fifth column of the preceding table; the sign + denoting that the observed length is greater than the calculated length.

The sum of the positive residual errors is +0·0440, and of the negative residual errors −0·0423.

Thus the formula agrees well with the equations of condition. With regard to individual errors, they depend upon errors of observation and upon anomalies in the intensities of terrestrial gravity; but it is difficult to discover in the differences given above any certain traces of those anomalies and of the local causes which produce them.

"In the work of W. Struve on the arc of meridian between the Danube and the Arctic Sea is a detailed discussion of the latitudes of the principal places between the North Cape and the Danube. The differences in latitude found directly from the astronomical observations vary only $\pm$ 1″·75 from those deduced from the geodetical operations. Athough these differences are very much larger than the errors of observation, they are not as great as those which may be found in corresponding operations in other countries. Our stations are in the neighborhood of the places discussed by M. Struve; so that it appears that in the great plains of Western Russia the directions and intensities of gravity are not subject to anomalies which change sensibly from one of our stations to another."

4. *Zoological Results of the* 1870 *Dredging Expedition of the Yacht* "*Norna*" *off the coast of Spain and Portugal;* by W. S. KENT.—A detailed list of the numerous species collected throughout the cruise being in course of preparation for the more technical and exhaustive report to be presented to the Royal Society, I here propose, commencing at the lowest animal group, to briefly enumerate some of the more important forms taken, adding such remarks on the characters or connecting circumstances which render them more especially deserving of attention. Of all, the sub-kingdom of the Protozoa has perhaps furnished us with the most abundant and valuable material, the sponge class in particular contributing many novelties. Before leaving British waters even, the few hours spent in shore-collecting at Guernsey, already alluded to, resulted in the accession of three new species of the genera *Isodictya* and *Hymeniacidon*, which I have placed at the disposal of my kind friend Dr. Bowerbank, to be described by him in his supplementary volume of the "British Spongiadæ," now closely approaching completion. The moderate depth within the Laminarian and Coralline zones, from the shore line down to fifty fathoms, at which we collected and dredged in Vigo Bay and afterward farther south in the neighbourhood of Setubal and the Sado river, proved remarkably productive of species belonging to the same group, as also to that of the Calcarea or calcareous spiculed sponges, including *Sycon* and *Grantia*, &c. The most interesting of any, however, were the species belonging to the Hexactinellidæ, or hexradiate spiculed sponges, of which the beautiful *Euplectella* and *Hyalonema* form familiar examples. Nine species belonging to this group were obtained at a depth varying from 400 to 800 fathoms off Cape Espichel and Cezimbra, including *Hyalonema*, *Dactylocalyx*, *Aphrocallistes Bocagii*, *Lanuginella pupa*, and four other species new to science, three out of which necessarily constitute the types of new genera, the residue again furnishing data enabling us better to appreciate the characters and distinctions of those previously made known to us. The form belonging to the same group, and described by myself as *Pheronema Grayi*, and exhibited at the last meeting of this Association, is the most conspicuous among all these on account of its size, and I would here add a few more words in reference to this particular type. Since last year I have been afforded the opportunity of examining and comparing my own with numerous specimens of Prof. Wyville Thomson's *Holtenia Carpenteri* taken in the North Sea and also in the Atlantic, and from an evolutionist's point of view, this examination has led me to regard my specimens as holding rather the rank of a well-marked local variety than of a distinct species as I at first premised. A comparison of the specimens, now placed side by side in the British Museum collection, will, I think, suffice to prove to all those interested in this subject how strongly marked as varieties these two forms are. Meanwhile, the generic name of *Pheronema*, adopted by myself, I still retain, as I consider both Prof. Wyville Thompson's form and my own to be local varieties of another species

first described by Dr. Leidy of Philadelphia as ***Pheronema annæ***, and a letter recently received from Dr. Leidy himself more fully convinces me of this, though he has not yet bestowed on it the minute microscopical investigation of its structure needed for the effectual clearing up of this, at present, doubtful point.

In my description of other sponges belonging to this same Hexactinellate group, read before the Royal Microscopical Society, and published in their "Transactions" for November, 1870, I have, in creating a new genus and species, ***Askonema Setubalense***, erroneously associated Prof. Thompson's name with it as having once pronounced the form to be of vegetable and not animal organization. The mistake arose from the misconception of a name singularly similar in euphony as pronounced to me by Prof. du Bocage, and I here avail myself of the opportunity of rendering Prof. Wyville Thompson that *amende honorable* I feel myself in duty bound to accord to him.

Passing next to the class of the Foraminifera, our gatherings have been remarkably rich both from the coralline and abyssal zones, the latter furnishing us with numerous arenaceous types (*Rhabdomina*, &c.), and the former being notably abundant in species and varieties of *Lagena* and *Cristellaria*. Many of these forms are new to science and await description.

The Cœlenterate sub-kingdom has likewise furnished several new and rare forms, including among the latter category an example of *Hyalopathes pyramidalis*, M. Edw., one of the Antipathiidæ now represented for the first time in our national collection, if not in this country. In the Alcyonarian group, *Veretillum cynomorium*, first taken sparingly in Vigo Bay, and afterward abundantly in the Laminarian zone near Setubal, excited our warmest admiration.

Nothing can exceed the beauty of the elegant opaline polyps of this zoophyte when fully expanded, and clustered like flowers on their orange-colored stalk; a beauty, however, almost equalled by night when, on the slightest irritation, the whole colony glows from one extremity to the other with undulating waves of pale green phosphoric light. A large bucketful of these Alcyonaria was experimentally stirred up one dark evening, and the brilliant luminosity evolved produced a spectacle too brilliant for words to describe. The supporting stem appeared always to be the chief seat of these phosphorescent properties, and from thence the scintillations traveled onwards to the bodies of the polyps themselves. Some of the specimens of this magnificent zoophyte measured as much as ten inches from the proximal to the distal extremity of the supporting stalk, while the individual polyps, when fully exserted, protruded upwards of an inch-and-a-half from this inflated stalk, and measured as much as an inch in the diameter of their expanded tentacular discs.

Numerous Polyzoa were also dredged up from the various depths, many of which remain yet to be identified; but the allied group of the Tunicata has perhaps furnished by far the most inter-

iting material of the whole molluscoidan sub-kingdom; surface-kimmings one morning near the mouth of the Sado river having ewarded us with numerous specimens of an *Appendicularia*, hich, from notes and sketches made at the time of their capture, have since found to have presented phenomena seemingly not et observed by any other naturalist. Hitherto these organisms ave been presumed to constitute a distinct genus of Tunicata *iter se*, or otherwise to be the larval conditions of higher forms. Iy own observations, however, recorded in the last July number f the "Quarterly Journal of Microscopical Science," have led me believe that they are the free swimming reproductive zooids of igher Tunicates, bearing the same relation to them as many free vimming *Medusæ* do to some stationary hydroid colony. At e greater depth of 600 and 800 fathoms, various species of *Terebratulæ* were taken as representative of the class Brachiopoda.

Ascending yet higher to the sub-kingdom of the Mollusca, a rge variety of interesting species rewarded our researches. Inuded among these were—*Fusus contrarius*, a common fossil of e Norfolk crag recently discovered in the living state in Vigo ay by Mr. McAndrew, and dredged by us in the same locality; so a species of *Cassis*, remarkable from its being more closely lied to *C. Saburon* and other species inhabiting the Japanese d Chinese seas than to any of its Mediterranean or Atlantic coneners. This circumstance of its affinity is the more remarkable hen associated with the occurrence of a species of *Hyalonema* *H. lusitanica*) off the same coast, likewise scarcely distinguishable om the more familiar Japanese form *H. Sieboldi*.—*Nature*, *Oct.* 5.

5. *Destruction of the Museum of the Chicago Academy of ciences.*—Among the devastations of the great Chicago fire, not e least in importance was the burning of the Museum of the hicago Academy of Sciences. The building was supposed to be re-proof, but a letter to Professor Agassiz from Dr. Wm. Stimpn, the Curator, says, "it collapsed like a bubble in the intense eat, as did indeed all other 'fire-proof' buildings in the city." he Museum contained the largest collection of Crustacea in the orld, "filling," as the same letter says, "more than ten thousand rs," included the very extensive suite of specimens and species, en to the types of all the many new species, gathered by Prof. D. Dana in the Wilkes Exploring Expedition in the Atlantic d Pacific Oceans, the basis of his Report of 1,500 pages in 355 on that subject; and also the large collections made by Dr. timpson himself in his cruise in the Ringgold Expedition to the orth Pacific, besides his recent collections from the Gulf of exico, and specimens from various other sources. There were so the alcoholic specimens of other invertebrata, obtained by e Wilkes Exploring Expedition, and those of Dr. Stimpson's wn Pacific and Gulf collection. There were also in the Museum, nfortunately, the Crustacea dredged up by Mr. de Pourtales in s late dredging expeditions, these having been sent there for escription and a final report.

Dr. Stimpson writes, that besides his private collections, all his books and his manuscripts, the result of twenty years of labor, are gone. He says, "Everything of value that I had in the world was deposited in the building for safety, and I am now left utterly destitute." Dr. Stimpson had published only brief descriptions of the species collected by him in the North Pacific expedition, and had been engaged during the past two years, along with an artist, in preparing for the press a full report, with detailed illustrations of all the species. These are among the lost.

Dr. Stimpson is one of the ablest and most energetic workers in zoology in the country; and he deserves something more than ordinary commiseration. Should a scientific library be restored to him by gifts from others over the world, and from owners of duplicate copies of zoological works, it would not be more than a just return for all his unwearied labor in the cause of science.

6. *Earthquake in New Jersey, Delaware, and Pennsylvania;* by W. C. Taylor. (From a letter to Prof. Newton, dated Haddonfield, N. J., Oct. 10, 1871.)—The earthquake which was felt in Delaware yesterday was very distinctly observed in this place. The time noted by one of our school teachers here, an exact observer, was 20′ before 10 A. M., the same as that stated by the Wilmington writers.

The noise heard in Haddonfield was similarly described by all observers as resembling the dragging of heavy furniture over the upper floors of the houses, or the rumbling of heavily-laden wagons along the streets. It was sufficiently startling to bring some persons to their doors, to look for the cause of the disturbance.

In a subsequent letter, Mr. Taylor states that the shock was felt also in Philadelphia, at the same time, 20′ before 10. The shock was felt at Dupont's powder mills, where there was not an explosion, as has been suggested.

OBITUARY.

Peter D. Knieskern, M. D., died at Shark River, New Jersey, on the 12th of September last. He was born at Berne, Albany county, N. Y., June 11, 1798. When a boy his love of nature and of books was such that his father despaired of making a farmer of him, and he consequently, but with great difficulties, found his way to a liberal education. He took his medical degree about the year 1829 or 1830, at Fairfield (College of Physicians and Surgeons of the Western District,) N. Y., then a famous school of medicine. He early became passionately fond of Botany, was an indefatigable collector and a keen observer. Few botanists have excelled him in their knowledge of the plants of the region in which he resided, and none in zeal, simplicity and love of science for its own sake. Neither poverty nor want of opportunity and companionship appear to have discouraged him, although they restricted his researches to a comparatively narrow field. He first established himself, as a physician, at New London, then removed to Oriskany, N. Y. He published in the Report of the Regents of the University for 1842, a catalogue of plants of

Oneida county, of which Dr. Torrey took occasion to speak in the highest terms, while also acknowledging the most efficient aid which Dr. Knieskern had rendered him in the preparation of his Flora of the State of New York. In the year 1841, upon Dr. Torrey's recommendation, he removed to a new field, which seemed to offer an opening for a medical man, while it afforded a richer harvest of rare plants than any other district in the Northern Atlantic States, viz: the Pine barrens of New Jersey. He lived first at Manchester, Ocean county; six years later he removed to Squam Village, Monmouth county, and six years afterwards to Shark River, where he remained to the end. Over this whole prolific and peculiar pine-barren region he botanised with utmost assiduity and skill, and amassed a large number of specimens, which, as age advanced have accumulated on his hands, and which, it is hoped, may be disposed of for the benefit of his family. It should be especially rich in Carices, to which he devoted much attention; and several most interesting species are almost peculiar to that district or even to some few localities in it. The character of that flora may be gathered from the catalogue of the plants of parts of Ocean and Monmouth counties, New Jersey, which Dr. Knieskern published, and from a greatly extended edition of it which subsequently appeared as a contribution to the Geological Survey of the State. What particular course will be adopted in reference to these botanical *reliquiæ*, the writer of this notice is at present unable to say. But those wishing for information may address communications to him, or, which is better, to the Rev. Samuel Lockwood, Freehold, New Jersey, to whom we are indebted for the facts relative to Dr. Knieskern's later life. He informs us that his lamented friend died of paralysis, in his 74th year, with unclouded intellect, the same simple-hearted, truly but most unpretendingly good and faithful man that he had always been. At least two species of his own discovery bear his name, and both are of the Sedge Family, in which he especially delighted. These, and the repeated mention of his discoveries in various works will keep his memory green and name perennial in American Botany long after the few surviving companions of his youth have passed like him to another world. A. G.

John Edwards Holbrook, of South Carolina, died at Norfolk, Massachusetts, on the 8th of September. He was born at Beaufort, S. C., in 1794, and graduated at Brown University; and since 1824 has occupied the position of Professor of Anatomy in the State University of South Carolina. He is chiefly known from the extent and magnificence of his works upon the reptiles of North America, and upon the fishes of South Carolina. Of these the first-mentioned appeared in its completed form in 1842, occupying five quarto volumes, and giving figures and descriptions of all the species of reptiles then known in the United States—about one hundred and sixty in number. Some volumes had been previously published and canceled by the author in consequence of their supposed imperfection. The advance in our knowledge of American

reptiles since that time may be learned from the fact that we are at present acquainted with not far from five hundred species.

The work on the fishes of South Carolina was equally difficult to bring to a conclusion satisfactory to its author, several numbers having been canceled and replaced. The publication, indeed, was never entirely finished, the commencement of the civil war having interfered with its completion, although, as it stands, it embraces the only available series of illustrations of the greater part of the Southern species. It is said that a eulogium upon Dr. Holbrook is to be delivered before the Boston Society of Natural History by Professor Agassiz at some future day.—*Harper's Weekly.*

JAMES DE CARLE SOWERBY, died August 20th, at the age of 84. Mr. Sowerby was well known as a naturalist; still better, however, as an artist, his illustrations of shells, plants, and other objects of natural history being considered of superior excellence, and gracing the pages of many of the more important works of natural history published in England for many years past. It was in the branches of conchology and botany that he was most prominent; in the latter department, mainly in connection with what is known as "Sowerby's English Botany," intended to give a life-size colored figure of every British plant; and of which eighty-one fasciculi, or ten volumes, are already published at a cost of over $10,000 per set.—*Athenæum.*

SIR RODERICK IMPEY MURCHISON, the eminent geologist, died in London on the 23d of October, aged 79, having been born in 1792.

V. MISCELLANEOUS BIBLIOGRAPHY.

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2. *Earthquakes, Volcanoes and Mountain building*; by J. D. WHITNEY. 108 pp. 8vo.—Three articles published in the North American Review. A valuable and interesting discussion of many of the views connected with the three subjects mentioned in the title, with the results of the author's own important investigations.

3. *The Minerals and Geology of Central Canada: a hand-book for practical use*; by E. J. CHAPMAN, Prof. in University College, Toronto, and Consulting Mining Engineer.—This is a second and enlarged edition of Professor Chapman's Hand-book. It contains the only systematic account of Canadian Mineralogy, and a brief sketch of its Geology.

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THE

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ART. XLIX.—*On the Geological History of the Gulf of Mexico;* by E. W. HILGARD, of the University of Mississippi.* With a Map.

THE colored outline map before you, without much pretension to accuracy of detail, shows the general geological features of the great embayment, once a portion of the Gulf of Mexico, whose axis is now marked by the course of the Mississippi river, from southern Illinois to its mouth. I have compiled this map from the best data now extant, accessible to me, with a view to the better elucidation of the succession and character of geological events; and especially with a hope of bringing to bear upon the later formations of the interior of the continent, the chronological record here left by the retiring waters of the sea. Marine deposits being better understood and more available for general comparison and conclusions than those of inland lakes, the series here shown would seem, by its original connection with the interior basins, to promise a key to the determination of equivalence in time, that, in view of the violent disturbances in the Rocky Mountain region, it might be difficult to find in that portion of the continent.

The subject matter of the present communication is, for the greater part, embraced in publications made by myself during the past ten years; and to these publications I must refer for the corroborative detail, which in this general summary would be out of place.

* Read before the American Association for the Advancement of Science, at Indianapolis, August, 1871.

Cretaceous period.

The most ancient shore-line of the Mississippi embayment is formed mainly by the various stages of the Carboniferous rocks. It is only in eastern Alabama and the adjoining portion of Georgia, that the Silurian and metamorphic rocks formed the shore of the Cretaceous seas. The deposits of the latter period have been traced by Safford up to the Kentucky line, along the western foot of the paleozoic ridge which compels the Tennessee river to make its long détour northward; and the Cretaceous outcrop doubtless extends, in a northwesterly direction, some distance into Kentucky.

In the portion of this belt embraced within the States of Mississippi and Alabama, the dip is sensibly at right angles to the trend (i. e., between W. and S.) at the rate of twenty to twenty-five feet per mile. In its southerly portion especially, the Cretaceous beds are very distinctly divided into three principal stages, viz:

1. A lower one 300 to 400 feet thick—*Coffee group* of Safford (Eutaw group *mihi*)—consisting of non-calcareous sands, and blue or reddish laminated clays, with occasional beds of lignite, and but very rarely (Finch's Ferry in Alabama) marine fossils, silicified; corresponds doubtless to Hayden's Dakota group, including, perhaps, in its upper part the equivalents of the Fort Benton group, to whose fossils those of Finch's Ferry, collected by Tuomey, bear a close analogy.

2. The middle or Rotten limestone group, not less then 1,200 feet in maximum thickness. Soft, mostly somewhat clayey, whitish, micro-crystalline limestones and calcareous clays; very uniform on the whole, if we except the locally important, but not generally extant, feature of the "Tombigby Sand," the special home of Inocerami, Selachians, and gigantic Ammonites.

3. Ripley group: crystalline, sandy limestones, alternating with dark colored glauconitic marls containing finely preserved fossils. Thickness 300 to 350 feet. Equivalent of the highest bed of the Cretaceous of New Jersey, and doubtless of Hayden's Fox Hills beds.

How far the Rotten limestone, as a whole, may be considered as embracing the whole of the series intervening between Hayden's Fox Hills beds and Dakota group, remains to be shown. The fauna of the Tombigby sand sub-group is distinguished, as already stated, by the great number, both of individuals and species of Inocerami, and of remains of (chiefly Selachian) fishes, wherein it corresponds to Hayden's Niobrara division; its fossils have been partly named and described (somewhat imperfectly) by Tuomey.* According to Hayden's view of the New Jersey

* Proceed. Philad. Acad.

equivalents, the Rotten limestone would be represented by his Fort Pierre group.

The distinctive features of these several groups become less marked the farther we advance northward, even in Mississippi. Non-fossiliferous or lignitic clays and sands mingle with the marine strata; and become altogether predominant, it would seem, near the northern termination of the outcrop.*

West of the Mississippi, the continuous Cretaceous outcrop does not extend as far northward as on the east side, by some 150 miles. Nor have the more ancient lignitiferous beds (Coffee group) been observed there, with certainty, within the limits of this map. The Cretaceous area of Arkansas, according to Owen's description, falls almost altogether within the limits of the Rotten limestone group; and the same seems to be true of the greater part of the Cretaceous area of northern and middle Texas. Nevertheless, the series of isolated Cretaceous outliers, which traverses Louisiana from the head of Lake Bisteneau in a S.S.E. direction, terminating probably in the great rock-salt mass of Petite Anse†, exhibit the main characteristics of the Ripley group; while deep borings have demonstrated the presence, for a thousand feet beneath, of the uniform Rotten limestone, such as it exists on the prairies of Mississippi and Alabama. I have elsewhere‡ stated the stratigraphical as well as lithological reasons which induce me to consider both the rock-salt of Petite Anse, and the sulphur and gypsum deposits of Calcasieu, as lying within the limits of the Cretaceous formations.

The data given by D. D. Owen seem to assign to the Cretaceous strata of Arkansas a dip S. or slightly W. of S. The outliers in Louisiana are too limited in extent for determinations of dip; but it can scarcely be doubted that they represent the summits of a (more or less interrupted) ancient ridge, a kind of "backbone" to the State of Louisiana, whose resistence to denudation has measurably influenced the nature and conformation of subsequent deposits. It is fair to presume that from this ridge the strata dip toward the axis of the Mississippi Valley, to meet those on the opposite side; and the depth at which these beds are found in the Calcasieu bores, seems to indicate, on the western slope, a south-southwesterly dip of three to four feet per mile. A glance at the map shows, nevertheless, that the general form of the northern Gulf shore was not materially influenced by the existence of this axis of elevation, which probably was marked merely by a series of disconnected islands in the early Tertiary sea that, after the emergence

* Fide Safford.

† Indicated on the map by the localities of Petite Anse, Chicot, Winfield and Bisteneau.

‡ This Journal, Nov., 1869, p. 345.

of the immence Cretaceous area, already prefigured the present Gulf of Mexico.

It would be bootless to speculate, at this early moment, on the precise origin of the great rock-salt, gypsum and sulphur deposits. That the prominent event of the epoch—the emergence of an extensive sea-bottom—afforded abundant opportunity for the accumulation of the two former substances, is obvious enough; it would seem to pre-suppose, however, a temporary or partial isolation at least from the general ocean, analogous to that which, apparently, occurred in later times. But as regards the sulphur, its ordinary co-occurrence with gypsum would hardly seem to afford a sufficient precedent for the present case; unless we assume the concurrent influence of volcanic or other "abysso-dynamic" agencies.

Tertiary period.

It will be perceived that during the Tertiary period, the northern Gulf shore receded from its extreme northern limits in southern Illinois and Missouri, to a shore-line which, though running near the latitude of Bâton Rouge, is not far from parallel to the present one, if we ignore the extreme projection of the Mississippi delta. This rapid filling-in of the embayment, no less than the character of the deposits, prove that the depth of water was not great; especially in the remoter portions, where lignitic and lignito-gypseous deposits very sparingly interspersed with small marine beds (the remnants of estuaries) from the predominant material. Similar alternations of materials occur, in fact, throughout the older Tertiary deposits of the southwest; and hence, the divisions marked off by difference of color on the map, as "lignitic" and "marine" Tertiary, respectively, must be taken very much *cum grano salis.* Except only in southern Arkansas, few marine beds of any notable extent occur outside (i. e., north of) the limit of the area indicated as marine. But in northern Louisiana, where the dip is very slight, lignitiferous strata are altogether predominant on the surface; although the marine seem to underlie everywhere at no great depth, and in numerous localities crop out on the surface; forming, according to Hopkins, distinct beaches around some of the Cretaceous outliers mentioned above.

So far, indeed, from considering the predominantly lignitiferous area as representing a period distinct from the older marine Tertiary, I have little doubt that the larger portion, if not all, of the beds I have heretofore designated as the Northern Lignitic (and Flatwoods clay) group (Lagrange and Porter's Creek groups of Safford) are the striot equivalents in time of the oldest marine beds observed in South Carolina and Alabama, and designated

by Tuomey as the Buhrstone group ("Siliceous Claiborne" of my Miss. Report). The lithological continuity of the bed-rocks of this group along the eastern border of the Tertiary, supported to some extent by paleontological evidence, strongly inclined me to this opinion ten years ago;* and it has received a strong confirmation from the latest observations of Dr. E. A. Smith, of the Miss. Geol. Survey, who has found the same rocks, substantially, continuous along the southern border of the lignitic area, nearly to the Mississippi bluff. At the same time, Safford mentions the occurrence of similar beds on the border of the Cretaceous, in Tennessee. The inference is inevitable that no beds outcropping in the fork of these two marine branches can be anterior in time; the interconnection, in fact, is such as to render the supposition that there can be any material difference of age almost stratigraphically impossible. The exclusively lignitic character of the central portion must, therefore, be ascribed rather to the inaccessibility of that region to the waters of the sea during their deposition; perhaps in consequence of a change of level, by which the upper portion of the embayment, from about the mouth of the Arkansas to Cairo, was converted, for the time being, into a littoral marsh.

In Arkansas, nevertheless, small marine beds are more liberally interspersed among the lignitic clays, than is the case east of the Mississippi; and some of those mentioned by Owen as occurring on the territory here laid down as chiefly lignitic, are obviously more closely related to the celebrated Claiborne shell-bed than to the Buhrstone group. The latter group does not, in fact, appear characteristically developed anywhere west of the river, so far as I know; and the occurrence of somewhat extensive marine Tertiary outliers on the Cretaceous territory of Arkansas, as well as of lignitic beds on that of Texas (e. g., the Cross Timbers, as approximately laid down on the map), proves that although the deeper water of the embayment followed substantially the lines of trend shown on the map, yet there still existed at that time a connection, in a northwesterly direction, of the Gulf waters with those of the great interior basin of the West.

That this connection should not be uninterruptedly traceable at the present time, is not surprising when we consider the shallowness of the connecting trough, as demonstrated by the inconsiderable thickness of the deposits, that of course greatly favored their removal by the subsequent events of the Quaternary period. Nevertheless, enough seems to remain of these deposits to form a chain by which, with the aid of paleobotany, the equivalents in time of the Buhrstone and Claiborne marine groups, at least, can be determined among the fresh or brackish-

* Miss. Rep., 1860, §§ 162 and ff. 188, etc.

water beds of the interior. And with these as fixed horizons to start from, aided also by the flora of the subordinate lignite beds of the later (Jackson and Vicksburg) stages, we may hope to establish a comparative chronological scale through which the parallelisms with more distant regions, and later times, may be established even for the much-discussed Tertiary beds of the Great West.

My present purpose scarcely requires that I should more than allude to the detail of the later stages of the older Tertiary, which I have not distinguished on the general map, in order not to obscure too much the general features. But a detailed map shows both the successive decrease in the width of their outcrops, and the regularly diminishing convexity of the Gulf-outline. I may also add that as we recede from the vertex of the embayment, and eastward from its axis, there is a regular increase of deep-sea features, the lignitic facies becoming more and more subordinate; yet, by its persistent recurrence seeming to intimate the occurrence, if not of oscillations, at least of local variations of depth; dependent, perhaps, upon corresponding changes in river mouths. In Alabama, the lignitic feature is almost suppressed, the marine stages overlying each other directly, as a rule; while west of the Mississippi, it becomes more and more pronounced as we advance westward, so that all but the latest portion of the Jackson, and most of the (much diminished) Vicksburg sea, here represented, appears to have been an intricate maze of everglades and shallow estuaries. That this state of things is intimately connected with the existence of the Cretaceous "backbone" of Louisiana on one hand, and the decided southward dip of the same formation in Alabama on the other, can scarcely be doubted. At the same time, let it be remembered that both east and west of the Mississippi, from the Chattahoochee to the Sabine, the older Tertiary period closes with a decided prevalence, in the Vicksburg limestones, of the deep-sea character; and thus far, the geological history of the gulf does not exhibit any phenomena whose parallel may not, *mutatis mutandis*, be found on the coast of the Carolinas. Moreover, the transition from the oldest to the more modern (Vicksburg) fauna is so gradual, gaps existing in Alabama and Mississippi being completely filled by transition strata observed by Hopkins and myself in Louisiana, that any attempt at subdivision into eocene and "oligocene" must draw altogether artificial lines of demarcation.

But while on the Atlantic coast we meet, in the Miocene and Pliocene strata of Maryland, Virginia and the Carolinas, a gradual approximation to, and admixture of, modern marine forms, the Vicksburg epoch closes abruptly, so far as the Gulf of Mexico is concerned, the marine Tertiary series. The geolo-

gically as well as agriculturally barren rocks of the *Grand Gulf* age lack all analogy outside of the Gulf basin, unless it be those of the Bad Lands of Nebraska, and especially the White River beds, to which they bear an extraordinary lithological (as well as in some respects, stratigraphical) resemblance. However little this circumstance may prove as regards equivalence in time, we must, nevertheless, not forget that, as the only representative of the geological period intervening between the eocene and the Drift on the Gulf shores, the Grand Gulf group almost necessarily embraces among its equivalents these very beds; and since Marsh has found the latter so much farther south than they were supposed to exist but a short time ago, it is not altogether impossible that more direct relations between the two may yet be proven. The Grand Gulf rocks form the highest ridges of Louisiana as well as of south Mississippi, falling off rather abruptly into the level prairie country of the marine Tertiary. But even these ridges are capped by the ferruginous sandstone of the southern drift, which may have been instrumental not only in greatly diminishing their height, but also in sweeping away the links connecting them with the interior; as has unquestionably happened with regard to the older Tertiary.

Be that as it may, whether actual connection existed or not, we cannot escape the conclusion that analogous circumstances were required to produce analogous deposits. Foremost among these was *the exclusion of the sea;* nor can we account for the extreme scarcity of both animal and vegetable remains, that scarcely leaves us a hope of direct identification, unless upon the supposition that the water which deposited these beds was, take it altogether, too fresh for a salt-water fauna, yet too salt to admit of a fresh-water population. The solitary fragment of a turtle, recognized by Prof. Marsh, is all that has so far rewarded my many years' search for zoögene fossils in this formation ; and with the exception of a single locality in Mississippi, not yet fully explored, the prospect for recognizable fossil plants is about equally discouraging.

I confess that such absolute dearth of life rather staggers my belief; and my later observations on the deposits of the Port Hudson (Quaternary) beds have led me to conclude, that in some degree this absence of life is only apparent; and that the *calcareous concretions*, so abundant in some of the clay strata of the formation, are but the substance of perhaps a very diversified fauna, whose calcareous portions have been thus transformed by maceration.* The calcareous ingredient, however, occurs only in the lower, clayey division of the series; and it is sufficiently remarkable that the fine sand- and clay-stones of the

* This Jour., Jan., 1869, p. 81; Ibid., Nov., 1869, p. 338.

upper division should have preserved no vestiges of either animal or vegetable life.

I do not see how, in view of the nature, thickness (about 250 feet) and wide distribution of this formation, the inference can be avoided that during the whole or a part of the interval between the Vicksburg and Drift ages, the Mexican Gulf was, by some means, isolated from the Atlantic ocean; or that at least its communication, perhaps across the still submerged peninsula of Florida, was so imperfect as to render the influx from the interior of the continent predominant over the original supply of sea-water. An upheaval of the northern borders of the Caribbean basin could easily accomplish this result, so long as the deep channels excavated by the Gulf stream in the strait of Yucatan, as well as those of Florida, did not yet exist. Too little is as yet known with accuracy regarding the geology of the nearer Antilles and Yucatan, to determine whether they bear the marks of the event recorded by the Grand Gulf rocks on the northern shore of the basin. The observations of Mr. Gabb in Sto. Domingo, and of the English geologists in Jamaica, seem to indicate the existence there of marine Miocene and Pliocene tertiaries, which are altogether unrepresented in the waters of the Gulf. It has been suggested to me that beds of that character may be covered by the Grand Gulf and later beds of the Gulf coast. I willingly leave the onus of proof on that score to those who may think such an assumption desirable. But were this the case, the necessity for assuming the cutting off of the Gulf basin from the Atlantic, on account of the existence of the Grand Gulf rocks, would be none the less cogent; for I doubt whether any geologist, upon full consideration of the facts, would for a moment entertain the idea that like the "Northern Lignitic" of the older Tertiary, the Grand Gulf beds could be explained away as a mere littoral formation.

It is worthy of remark that while east of the Mississippi, the peculiar sand- and clay-stones of this group are confined to the northwesterly portion of its area of occurrence, in Louisiana and eastern Texas these rocks are altogether predominant, especially along the northern (or landward) border, the clays being subordinate.

Quaternary beds.

The Grand Gulf rocks are almost everywhere immediately overlaid by the deposits of the stratified Drift or Orange Sand. Of course it overlies equally, as a rule, the more ancient formations (except where, from causes not always readily imagined, it seems to have been subsequently removed) up to the limits of the Paleozoic. Beyond these, its occurrence is more or less localized in conformity with the larger valleys, as observed by

Safford in Middle and Eastern Tennessee, and by Tuomey and myself in Alabama. The same is true, apparently of the larger channels of Texas. But within the limits of the Mississippi embayment, it constitutes one huge delta-shaped mass, covering the entire Tertiary, and a large portion of the Cretaceous area, to a depth varying from a few feet to over two hundred; on an average, perhaps, between sixty and one hundred feet. Its predominant material is orange or reddish, rounded sand, mostly ferruginous, of various degrees of induration, with subordinate beds of clay, and enormous gravel-streams, evidently denoting ancient channels.* Its beds disappear beneath those of the Port Hudson age about concurrently with those of the Grand Gulf era; and consequently, it cannot well be independently represented on the map.

I have heretofore† shown that in order to explain the phenomena offered by the Orange Sand of Mississippi and Louisiana, it seems necessary to assume that prior to its deposition, the Gulf coast suffered an elevation to the extent of at least 450 feet above its present level, accompanied by a much greater uprising near the head of the waters. This elevation was succeeded, during the "Champlain" epoch, by a slow depression to at least twice that amount; and finally, during the Terrace epoch, a re-elevation to at least the extent of 450 feet took place. These figures are *minima*, if we regard the sea- or rather the Gulf-level to have remained constant. But if, as seems necessary to assume, the Gulf was an isolated basin during the Grand Gulf era, it might possibly have been elevated as a whole, and the zero-point of the scale would be changed upward, accordingly. The same, in a reverse direction, would be true if it could be assumed that the occurrence of the glacial epoch sensibly affected the general level of the ocean.

Be that as it may, the gravel is composed of northern rocks, disposed in belts, of which one occupies the main axis of the embayment, while others mark outlets now closed; and the extensive denudation and violent plowing-up of the more ancient formations, clearly proves the occurrence of an immense flow of waters southward, which in the main channels moved pebbles of many pounds weight; while between these, the deposition of the finer materials took place in more quiet waters.

That these events were not of a local character; that on the contrary, the phenomena observed in the Southern States are but the necessary consequence and complement of the Drift phenomena at the North, hardly requires discussion; but it is time that these facts were more generally understood and taken into account by American geologists, and that the Ohio should

* Miss. Rep., 1860, this Jour., May, 1866, and other papers above referred to.
† This Jour., Nov., 1869, p. 335.

It would seem that here also, during the latter porti Drift period, most of the larger river channels were impressed upon the surface, though not always coinci the present immediate valley; as Newberry has ob relation to some of the northern rivers. A depressi land would gradually transform these channels into in with more or less stagnant fresh water down to a great distance from the then existing coast line; and thus op would be afforded for the formation of the swamp an deposits into which both the Mississippi and Red ri subsequently cut their channels. The banks of the Red well as, outside the present alluvial area, those of the m and bayous which border that stream, exhibit strata a identical in character with those observed near the of course, totally different from either the alluvial d the present time, or the adjoining tertiaries. The sa true, more or less, of the Mississippi and its mighty " According to the observations of Dr. E. A. Smith in t bottom, and my own in that of the Tensas, not onl clays with calcareous concretions (as characteristic of Hudson age as they are foreign to the alluvium of to quently crop out in the beds of the streams; but ma best lands of the "buckshot" kind, now situated ab flow, have clearly been formed by simple disintegratio strata, altogether independently of the river alluvium.

These results fully confirm, therefore, the statement m Gen. Humphreys,* that the Mississippi does not, as a ru in a bed formed of its own deposits, but has excavated i older geological formation. Wells exceeding fifteen or feet ordinarily strike these clays throughout the bot they do in the delta; and the analogy has been comple the repetition of the phenomena observed in driven w New Orleans,† at a point about fifty miles above Vic (Gen. Wade Hampton's plantation), where a tube well h nished a copious flow of combustible gas undiminis many months.

The swamp clays form, however, only the lower po the Port Hudson beds. Higher up, as shown at th Hudson bluff,‡ there lie yellow or whitish silts and pans." These form, also, a level terrace some miles in bordering the Tensas bottom; while high above it, on t tops of Sicily Island, on the Washita, lie the remnants Loess formation, the main body of which has succum the erosive influence of the Terrace epoch of elevati has, however, left a belt a few miles wide on the side of the valley, as shown on the map.

* Rep. on the Mississippi river, p. 98, et al. † This Jour., vol. i, 1871
‡ See profile in this Jour., Jan., 1869.

PI EMBAYMENT.

It would seem that here also, during the latter portion of the Drift period, most of the larger river channels were already impressed upon the surface, though not always coincident with the present immediate valley; as Newberry has observed in relation to some of the northern rivers. A depression of the land would gradually transform these channels into inlets filled with more or less stagnant fresh water down to a greater or less distance from the then existing coast line; and thus opportunity would be afforded for the formation of the swamp and lagoon deposits into which both the Mississippi and Red river have subsequently cut their channels. The banks of the Red river as well as, outside the present alluvial area, those of the many lakes and bayous which border that stream, exhibit strata absolutely identical in character with those observed near the coast, yet, of course, totally different from either the alluvial deposits of the present time, or the adjoining tertiaries. The same holds true, more or less, of the Mississippi and its mighty "bayous." According to the observations of Dr. E. A. Smith in the Yazoo bottom, and my own in that of the Tensas, not only do the clays with calcareous concretions (as characteristic of the Port Hudson age as they are foreign to the alluvium of to-day) frequently crop out in the beds of the streams; but much of the best lands of the "buckshot" kind, now situated above overflow, have clearly been formed by simple disintegration of these strata, altogether independently of the river alluvium.

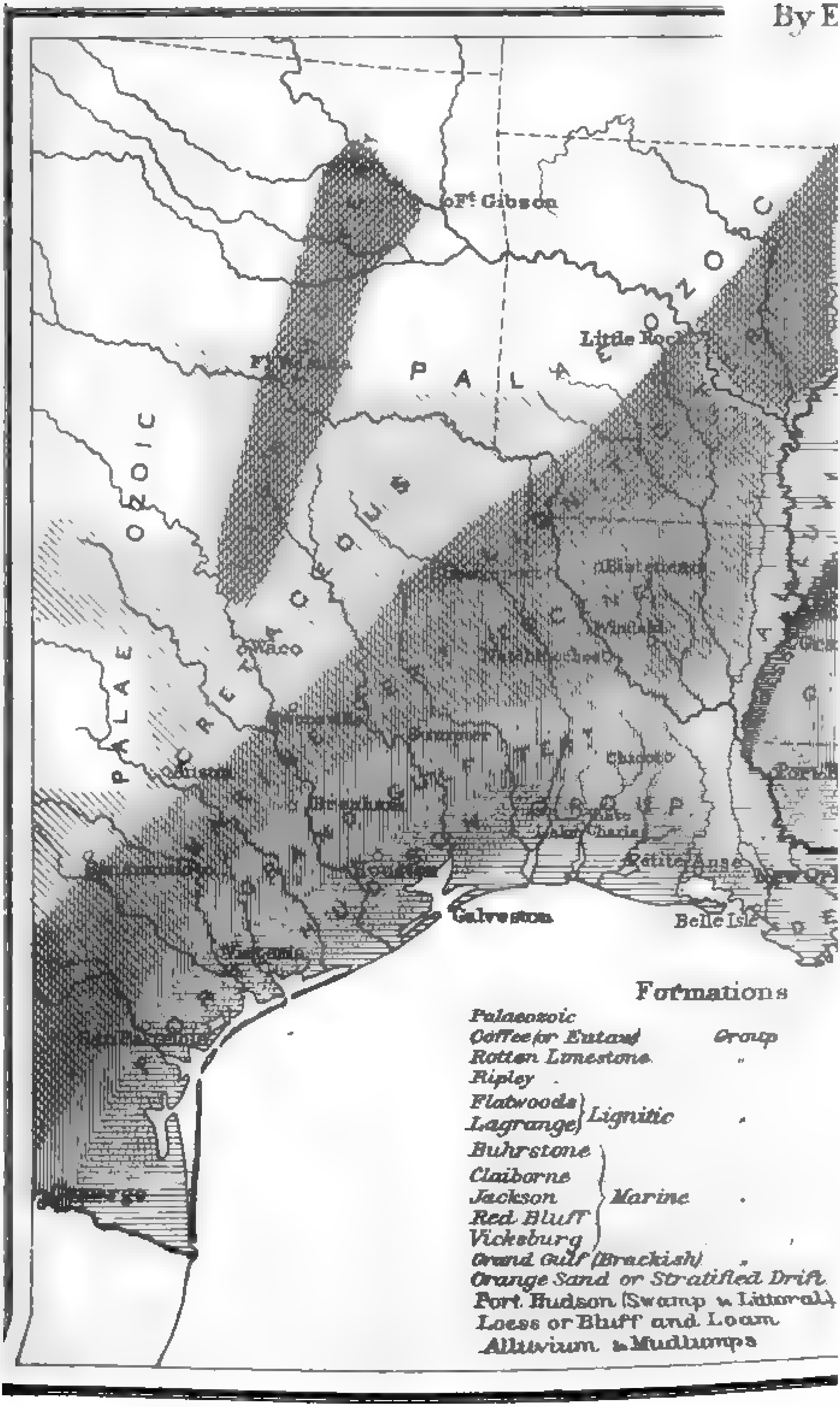
These results fully confirm, therefore, the statement made by Gen. Humphreys,* that the Mississippi does not, as a rule, flow in a bed formed of its own deposits, but has excavated it in an older geological formation. Wells exceeding fifteen or twenty feet ordinarily strike these clays throughout the bottom, as they do in the delta; and the analogy has been completed by the repetition of the phenomena observed in driven wells at New Orleans,† at a point about fifty miles above Vicksburg (Gen. Wade Hampton's plantation), where a tube well has furnished a copious flow of combustible gas undiminished for many months.

The swamp clays form, however, only the lower portion of the Port Hudson beds. Higher up, as shown at the Port Hudson bluff,‡ there lie yellow or whitish silts and "hardpans." These form, also, a level terrace some miles in width, bordering the Tensas bottom; while high above it, on the hill, tops of Sicily Island, on the Washita, lie the remnants of the Loess formation, the main body of which has succumbed to the erosive influence of the Terrace epoch of elevation. It has, however, left a belt a few miles wide on the eastern side of the valley, as shown on the map.

* Rep. on the Mississippi river, p. 98, et al. † This Jour., vol. i, 1871, p. 345.
‡ *See profile* in this Jour., Jan., 1869.

GEOLOGICAL MAP OF

By E



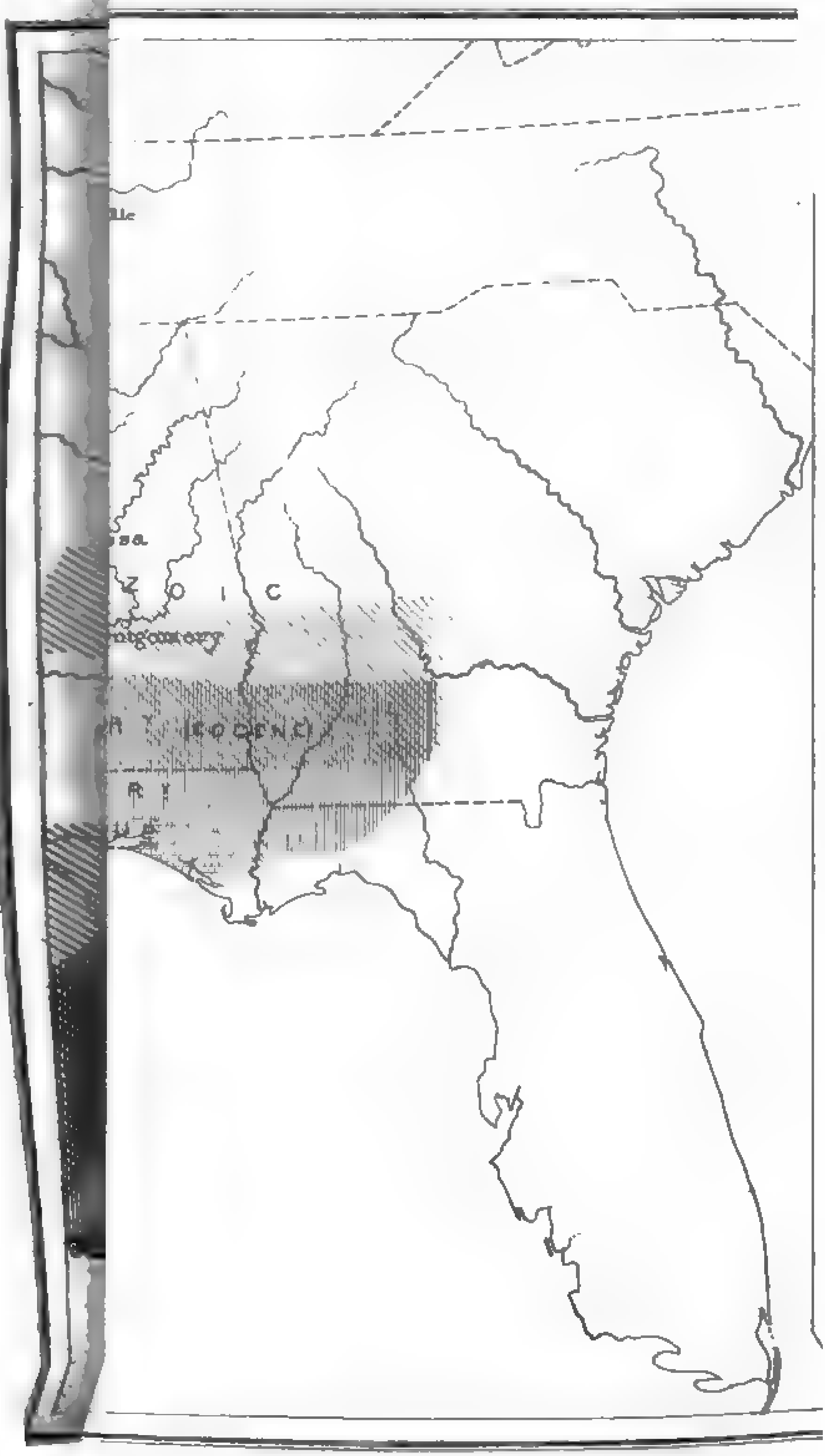
It would seem that here also, during the latter port Drift period, most of the larger river channels we impressed upon the surface, though not always coinc the present immediate valley; as Newberry has ob relation to some of the northern rivers. A depres land would gradually transform these channels into i with more or less stagnant fresh water down to a grea distance from the then existing coast line; and thus op would be afforded for the formation of the swamp a deposits into which both the Mississippi and Red ri subsequently cut their channels. The banks of the Re well as, outside the present alluvial area, those of the m and bayous which border that stream, exhibit strata a identical in character with those observed near the of course, totally different from either the alluvial d the present time, or the adjoining tertiaries. The sa true, more or less, of the Mississippi and its mighty " According to the observations of Dr. E. A. Smith in t bottom, and my own in that of the Tensas, not on clays with calcareous concretions (as characteristic of Hudson age as they are foreign to the alluvium of to quently crop out in the beds of the streams; but m best lands of the "buckshot" kind, now situated ab flow, have clearly been formed by simple disintegratio strata, altogether independently of the river alluvium.

These results fully confirm, therefore, the statement Gen. Humphreys,* that the Mississippi does not, as a r in a bed formed of its own deposits, but has excavated older geological formation. Wells exceeding fifteen or feet ordinarily strike these clays throughout the bo they do in the delta; and the analogy has been compl the repetition of the phenomena observed in driven New Orleans,† at a point about fifty miles above Vi (Gen. Wade Hampton's plantation), where a tube well nished a copious flow of combustible gas undiminis many months.

The swamp clays form, however, only the lower po the Port Hudson beds. Higher up, as shown at th Hudson bluff,‡ there lie yellow or whitish silts and pans." These form, also, a level terrace some miles in bordering the Tensas bottom; while high above it, on t tops of Sicily Island, on the Washita, lie the remnants Loess formation, the main body of which has succum the erosive influence of the Terrace epoch of elevatio has, however, left a belt a few miles wide on the e side of the valley, as shown on the map.

* Rep. on the Mississippi river, p. 98, et al. † This Jour., vol. i, 1871.
‡ See profile in this Jour., Jan., 1869.

PI EMBAYMENT.



It would thus seem that during the latter portion of the period of depression, the rate of sinking became, at times, too rapid to allow of the accumulation of swamp deposit. The indurate silts are mostly void of fossils of any kind, but are occasionally traversed by fluviatile beds with pebbles, driftwood, etc. Then there is a recurrence of the swamp deposits; then again silts; and finally, the calcareous, silty loam of the Bluff formation, with its numerous terrestrial fossils and "Löss puppets," ends the deposits clearly referable to the epoch of depression.

The Loess differs little from its equivalents farther north, save in being utterly devoid of stratification as well as of any fluviatile organisms. It is not easy to imagine the *modus operandi* by which a deposit of this kind, sometimes 70 feet thick, and of dead uniformity from top to bottom, could be produced. Its equivalents farther north exhibit very distinctly the structure resulting when deposition takes place in (gently) flowing water; at the south it was probably substantially stagnant, save as regards the tidal flow. Perhaps the latter may serve to explain both the absence of fluviatile as well as marine life, and the uniform intermixture, without any semblance of arrangement, of material varying from the finest silt to pebbles half an inch in diameter. A strong tidal wave running up a deep inlet of this kind, would naturally sweep away, in its periodical rushes, many members of the terrestrial fauna, whose remains are in a marked degree the more abundant the nearer we approach to the edge of the formation.

Overlying the Loess we find, wherever opportunity is afforded, a stratum of yellow loam or brick clay, which near the larger valleys is often as much as fifteen to twenty feet in thickness. It is altogether devoid of stratified structure, as well as of fossils, and forms the surface layer, and in most cases the subsoil of the Gulf States. If, as I am inclined to believe, its presence as a connected, though very undulating sheet, on all but the most elevated uplands of these States, necessitates the assumption of submergence, however brief, to the highest level at which it occurs; the changes of level heretofore alluded to would be shown to have exceeded by 600 to 700 feet the estimate given above.

The succeeding (Terrace) epoch of elevation has not, so far as I am aware, left any marks in the way of beach-lines or terraces, unless the second bottoms or "hommocks" be accounted such. They, however, belong to a very modern epoch, for they occur on streams no larger than what is usually called a "creek," and are most marked on the smaller rivers; while, apparently absent from those of the largest size, such as the Mississippi, Red and Arkansas rivers. The elevation at which,

on the very Gulf shore, we find deposits of the Port Hudson age (180 feet at the Five Islands on Vermillion Bay) shows, nevertheless, that a stupendous amount of erosion was accomplished during the time that the Mississippi occupied in scooping out its channel, to a depth which, even below the northern boundary of Louisiana, cannot be estimated at less than 500 feet.

As regards the modern epoch, I will merely remark that, while in the axis of the ancient embayment the Mississippi river, through the singular instrumentality of mudlumps upheaval, is rapidly pushing out the land into the Gulf waters, the latter are nevertheless gaining ground on almost the entire coast of Mississippi and Alabama; and the same is true of a portion of Vermillion Bay. Yet on the whole, the coast of Louisiana, as well as that of Texas and Florida, is more than holding its own; and the shallowness of the water, even where encroachment does take place, will necessarily restrict the latter within narrow limits hereafter.

ART. L.—*On the Astromonical Proof of a Resisting Medium in Space;* by ASAPH HALL.

THE return of Encke's Comet during the present year and its very favorable position for observation will attract the attention of astronomers to this, one of the most interesting bodies of our solar system. Besides the interest belonging to all periodic comets since the establishment of the probable connection of their orbits with those of meteoric streams, this comet has a peculiar interest, since from the singular anomaly in its motion Professor Encke drew his inference of a resisting medium in space. Encke's labors on the orbit of this comet were begun in 1819; and immediately after his discovery of its periodicity, he found by comparing the observations of that year with those of 1786, 1795 and 1805, and taking careful account of the planetary perturbations, the remarkable circumstance that the periodic times were diminishing. The following values of these times were found:

1786—1795	periodic time	=1208·112	days
1795—1805	"	" =1207·879	"
1805—1819	"	" =1207·424	"

In order to account for this diminution Encke adopted the hypothesis of a resisting medium in space. He appears to have been led to this hypothesis in the first place on account of its inherent probability, and in this view he was sustained by

Olbers. But the strongest proof of its truth lies in the fact that the analytical investigation shows, that a tangential force resulting from a resisting medium would produce secular changes in the mean motion of the body and in the excentricity of its orbit, leaving the other elements unchanged or changed by periodic inequalities only. This conclusion is independent of the law of density of the medium. Now this was what Encke needed in order to account for the anomalous motion of the comet, the change falling almost entirely on its mean motion, that of the excentricity being quite insignificant. Other hypotheses were suggested to explain the diminution of the periodic time, and especially that of internal changes in the comet itself, but nearly all of these, besides being less simple than the assumption of a resisting medium, would necessitate the introduction of forces acting in various directions, and producing anomalous changes in all the other elements of the orbit, contrary to what was required by the observations. Encke therefore, notwithstanding the doubts of Bessel and other astronomers, continued steadfast in his theory of a resisting medium in space, and for more than forty years, and until within a short time before his death in 1865, pursued his calculations with wonderful zeal and industry. Between the years 1829 and 1859, he published in the volumes of the Berlin Academy eight memoirs on the orbit of this comet, and also other investigations on the same subject in the Astronomische Nachrichten and in the Berlin Jahrbuch. He assures us, what we can easily believe, that he spared no labor and despised no precaution that could give completeness and surety to his computations; and besides being an excellent mathematician, Encke possessed, in a degree rarely equaled, the skill of adapting formulæ to convenient and safe forms for numerical calculations. He has given in the Berlin Jahrbuch for 1861 a résumé of his labors, and the proofs presented there, taken simply by themselves, seem to put beyond the shadow of a doubt two conclusions: first, that the periodic time of this comet is diminishing; and secondly, that this diminution is satisfactorily accounted for by the assumption of a resisting medium in space.

I will now state the reasons that throw doubt on the preceding conclusions, and which, I think, require that Encke's results should be tested by an independent calculation.

The position and dimensions of the orbit of Encke's comet are such that the comet can approach very near to Mercury, so near indeed, that notwithstanding the small mass of this planet, the perturbations which it may produce in the motion of the comet can exceed the greatest ever produced by Jupiter. On account of the rapid motion of Mercury, the calculation of

these perturbations would be very laborious, and frequent corrections of the comet's elements would be necessary. It is well known that among the incidental results of Encke's investigations on the orbit of this comet, were the corrections of the values of the masses of Jupiter, Mars and Mercury given by Laplace. The value of the mass of Jupiter is now accurately known, but with regard to Mars and Mercury there is an uncertainty which of course it would be necessary to consider in any investigation where these masses can produce large disturbances. Considering, therefore, the great difficulty of the problem, it does not seem unreasonable to ask, before accepting any extraordinary assumption, that Encke's results should be verified by a new calculation, carried on at least through four or five successive revolutions of the comet during recent times, when the observations have been accurately made. Encke himself has given in the Berlin Jahrbuch for 1858 a new and rigorous method for such calculations.

But should it be found, as seems probable, that Encke's numerical results are correct, it would not follow that the existence of a resisting medium in space is established.

There are two other periodical comets whose motions have been carefully investigated, and which furnish important evidence on this question. These are Faye's and Winnecke's comets, discovered, or in the case of the last rediscovered, in 1843 and 1858, and which have periods of 7½ and 5½ years respectively. If we denote by q the perihelion distance of a comet, by a its semi-major axis, and by e the excentricity of its orbit, and express these quantities in units of the earth's mean distance from the sun, we shall have the following values for 1858, when all these comets were observed.

Comet.	q.	a.	e.
Encke,	0·3407	2·2181	0·8464
Faye,	1·6942	3·8137	0·5556
Winnecke,	0·7684	3.1367	0·7550

If we observe that the aphelion distance is $2a-q$, the preceding quantities will give us an idea of how differently situated in space are the orbits of these three comets, and with what different velocities they move around the sun. Thus, while Encke's comet at its perihelion approaches nearer to the sun than Mercury, and always remains nearer than Jupiter, on the other hand, Faye's comet never approaches so near the sun as does the planet Mars. Should it be found, therefore, that all these comets exhibit in their motions the anomaly found by Encke, and could this be accounted for by the assumption of a resisting medium in space, the evidence would be considered decisive. Such, however, is not the fact. The orbit of Faye's comet has

been very carefully determined by Professor Axel Moéller of Lund, Sweden. After computing the planetary perturbations, Prof. Moéller combined the positions of the comet observed in 1843, 1851 and 1858, and at first thought it necessary to introduce, as Encke had done, the hypothesis of a resisting medium. In this way he satisfied the observations of the three returns in an admirable manner, and Encke in his declining years thought he saw the complete proof of his hypothesis and a satisfactory reply to Bessel's objection made in 1835, "that up to the present time we know of nothing but the motion of a *single* comet which it is necessary to explain by a resisting medium in space, since the motions of the planets and moon have given no evidence of a resistance." But in 1865 Prof. Moéller revised his calculations, and found that he had made an error in computing the pertubations, or rather in transferring the varying elements of the comet's orbit from one epoch to another, and that when this was correctly done the observations were satisfied, within the limits of their probable error, by a strict adherence to the law of gravitation and without any extraordinary hypothesis. Therefore, laying aside the theory of a resisting medium, Prof. Moéller carried forward his calculation of the perturbations, and computed an ephemeris for the return of the comet in 1865. This prediction proved to be of wonderful accuracy. The comet was so faint in that year, that it could be seen only with difficulty in the telescope of the Naval Observatory, but on the first night it was looked for it was seen exactly in the predicted place. Professor Peters of Hamilton College, who is provided with a more powerful telescope, made a series of accurate determinations of position and from the mean of eight days' observations the corrections of Prof. Moéller's ephemeris were only

$$\Delta\alpha = +0^{s}\cdot55, \ \Delta\delta = +9''\cdot9.$$

The prediction, therefore, was one of the most accurate ever made of the return of a comet. Hence in the case of Faye's comet, the weight of evidence was transferred from one scale to the other; and the character of the error, which Prof. Moéller detected in his own work, is such that there is additional reason for desiring that Encke's calculation should be subjected to a rigorous test.

Winnecke's comet was seen first in 1819, when Encke computed an elliptic orbit which gave very nearly the true periodic time, but the comet was not seen again until it was rediscovered by Dr. Winnecke in 1858. The most careful determination of its orbit is that by Professor Oppolzer of Vienna. As the perturbations of this comet have not been large, regard was had to the first powers only of the disturbing forces, and the calculations have been made with comparative ease. By combining

the positions of 1819, 1858 and 1869, Prof. Oppolzer finds for the first interval the value of the mean motion 638″·6312, and for the second interval 638″·7007. This difference is so small that we may safely conclude that the comet's motion is strictly in obedience to the law of gravitation.

Hence, so far as the motions of comets have been determined, the evidence is against the theory of a resisting medium in space. Thus far, the observations of the planets lead to the conclusion, that their motions are in strict accord with the law of gravitation; and in the disputes about the acceleration of the mean motion of the moon, no one has thought to seek its cause in a resisting medium, but much more probable causes are at hand. Encke's comet, therefore, stands alone in the strange anomaly in its motion which the calculations have shown. The first thing to be done would be to test the correctness of these calculations; and for this purpose it seems to me that the method of special perturbations is better than the expansion of the general perturbations, since by the first method all powers of the disturbing forces can be rigorously taken account of, while in the method of general perturbations the theory is difficult, and in the present state of analysis a doubt may remain whether we have included in our result all terms of a sensible influence. If it be proved that the diminution of the periodic time actually exists, this anomaly must be considered as a peculiarity of Encke's comet, and its cause must be sought for in something which distinguishes this comet from all others. It was early pointed out, by Olbers I think, that this comet moves through those regions where the zodiacal light is seen. Possibly also the numerous meteoric streams which are moving around the sun, and which are closely connected with the orbits of some of the comets, may exert an influence on their motions.

Sept. 25, 1871.

ART. LI.—*On a new Micrometric Goniometer eye-piece for the Microscope;* by J. P. SOUTHWORTH.

AFTER a few experiments by Dr. H. T. Porter and myself, we have succeeded in making an eye-piece micrometer and goniometer which equal in accuracy and surpass in simplicity and cheapness any we have seen, and we have used those of some of the best makers in this country. The objection to the eye-piece micrometers in use is the want of boldness in the division-lines, which makes them fatiguing and hurtful to the eyes. To overcome this objection we were led to experiments in making micrometers by the aid of photography, which have resulted in success. The steps of the process are these:—

1st. A scale of 100 heavy India ink lines about $\frac{1}{6}$ of an inch apart are drawn on a dead white surface of Bristol board. The lines marking every ten divisions are six inches long and extend one inch each side of the scale; those marking every five divisions are five inches long and extend one half inch beyond the scale; the remaining lines are four inches long.

2d. By photographic process for copying engravings, a negative is taken, on which the scale equals about two inches in length, and is intensified by mercuric chloride and potassium cyanide.

3d. With a copying camera and lens for taking transparent positives for the magic lantern, a transparent positive of this negative is taken on micrometer glass, reducing the scale to the length of one-half inch. In this the lines are $\frac{1}{200}$ of an inch apart. After intensifying, washing and drying, a cover of thin glass is cemented on with Canada balsam, and the slide cut to fit the slit in the micrometer eye-piece. It can be also mounted with a spring and micrometer screw, like Jackson's micrometer. In our micrometer the lines appear to stand out in relief, and are jet black, while the spaces between them are translucent enough to admit of the accurate measurement of the details of minute algæ and fungi to the $\frac{1}{25000}$ of an inch.

Regarding the goniometer:—

1st. A circle about eighteen inches in diameter is drawn with India ink, divided into degrees. The center is indicated by a dot, and one diameter is drawn. Every five and ten degrees are indicated by longer lines than those indicating single degrees. Every ten degrees of each quadrant are numbered from 0 to 90.

2d. A negative two inches in diameter is taken by the process referred to above, and from this a transparent positive is taken on a circle of micrometer glass cut to fit the tube of the microscope. It is covered with a circle of thin glass cemented with balsam, and mounted to fit the tube at the focal point of a positive eye-piece. A cobweb is drawn across the diameter of the lower lens. When a crystal is to be measured, the stage is moved till the apex of the angle coincides with the center of the goniometer and the diameter with one side. The eye-piece is now turned till the cobweb crossing the diameter at the center coincides with the other side of the angle. Now the number of degrees of the angle can be read at the circumference. The advantage of this over the ordinary microscopic goniometers is that in ours the angles of the crystal and the degrees of the goniometer are on the same line of sight within the tube of the microscope, while in the ordinary goniometer the degrees are marked outside the tube. The photographic processes by which the above are made can be learned by consulting any of the standard works on photography, under the sections that treat of copying engravings and taking transparent positives.

Georgetown, D. C.

ART. LII.—*On the bearing of Devonian Botany on Questions as to the Origin and Extinction of Species;* by DR. J. W. DAWSON.

[The theoretical views contained in this section, though necessary to give completeness to the subject, are not suitable for an official report, and are, therefore, printed separately by the author, for circulation to those who may be interested in them as matters of science.]

FOSSIL plants are almost proverbially uncertain with reference to their accurate determination, and have been regarded as of comparatively little utility in the decision of general questions of paleontology. This results principally from the fragmentary condition in which they have been studied, and from the fact that fragments of animal structures are more definite and instructive than corresponding portions of plants.

It is to be observed, however, that our knowledge of fossil plants becomes accurate in proportion to the extent to which we can carry the study of specimens in the beds in which they are preserved, so as to examine more perfect examples than those usually to be found in museums. When structure is taken into the account, as well as external form, we can also depend more confidently on our results. Further, the abundance of specimens to be obtained in particular beds often goes far to make up for their individual imperfection. The writer of these pages has been enabled to avail himself very fully of these advantages, and on this account, if on no other, feels entitled to speak with some authority on theoretical questions.

It is an additional encouragement to pursue the subject that, when we can obtain definite information as to the successive floras of any region, we thereby learn much as to climate, and vicissitudes in regard to the extent of land and water; and that, with reference to such points, the evidence of fossil plants, when properly studied, is, from the close relation of plants to those stations and climates, even more valuable than that of animal fossils.

It is necessary, however, that in pursuing such enquiries we should have some definite views as to the nature and permanence of specific forms, whether with reference to a single geological period, or to successive periods; and I may be excused for stating here some general principles, which I think important for our guidance, with special reference to the paleozoic floras which form the subject of this memoir.

(1.) Botanists proceed on the assumption, vindicated by experience, that, within the period of human observation, species have not materially varied or passed into each other. We may make, for practical purposes, the same assumption with regard

to any given geological period, and may hold that for each such period there are specific types, which, for the time at least, are invariable.

(2.) When we inquire what constitutes a good species for any given period, we have reason to believe that many names in our lists represent merely varietal forms or erroneous determinations. This is the case even in the modern flora; and in fossil floras, through the poverty of specimens, their fragmentary condition and various states of preservation, it is still more likely to occur. Every revision of any group of fossils detects numerous synonyms, and of these many are incapable of detection without the comparison of large suites of specimens.

(3.) We may select from the flora of any geological period certain forms, which I shall call *specific types*, which may for such period be regarded as unchanging. Having settled such types, we may compare them with similar forms in other periods, and such comparisons will not be vitiated by the uncertainty which arises from the comparison of so-called species which may, in many cases, be mere varietal forms, as distinguished from specific types. Our types may be founded on mere fragments, provided that these are of such a nature as to prove that they belong to distinct forms which cannot pass into each other, at least within the limits of one geological period.

(4.) When we compare the specific types of one period with those of another immediately precedent or subsequent, we shall find that some continue unchanged through long intervals of geological time, that others are represented by allied forms regarded either as varietal or specific, and as derived or otherwise, according to the view which we may entertain as to the permanence of species. On the other hand, we also find new types not rationally deducible, on any theory of derivation, from those known in other periods. Further, in comparing the types of a poor period with those of one rich in species, we may account for the appearance of new types in the latter by the deficiency of our information as to the former; where many new types appear in the poorer period this conclusion seems less probable. For example, new types appearing in poor formations, like the Lower Erian and Lower Carboniferous, have greater significance than if they appeared in the Middle Erian or in the Coal Measures.

(5.) When specific types disappear without any known successors, under circumstances in which it seems unlikely that we should have failed to discover their continuance, we may fairly assume that they have become extinct, at least locally; and where the field of observation is very extensive, as in the great coal fields of Europe and America, we may esteem such extinction as practically general, at least for the northern hemi-

sphere. When many specific types become extinct together, or in close succession, we may suppose that such extinction resulted from physical changes; but where single types disappear, under circumstances in which others of similar habit continue, we may not unreasonably conjecture that, as Pictet has argued in the case of animals, such types may have been in their own nature limited in duration, and may have died out without any external cause.

(6.) With regard to the *introduction* of specific types we have not as yet a sufficient amount of information. Even if we freely admit that ordinary specific forms, as well as mere varieties, may result from derivation, this by no means excludes the idea of primitive specific types originating in some other way. Just as the chemist, after analyzing all compounds and ascertaining all allotropic forms, arrives at length at certain elements not mutually transmutable or derivable, so the botanist and zoölogist must expect sooner or later to arrive at elementary specific types, which, if to be accounted for at all, must be explained on some principle distinct from that of derivation. The position of many modern biologists, in presence of this question, may be logically the same with that of the ancient alchemists with reference to the chemical elements, though the fallacy in the case of fossils may be of more difficult detection. Our business at present, in the prosecution of paleobotany, is to discover, if possible, what are elementary or original types, and, having found these, to enquire as to the law of their creation.

(7.) In prosecuting such questions geographical relations must be carefully considered. When the floras of two successive periods have existed in the same region, and under circumstances that render it probable that plants have continued to grow on the same or adjoining areas throughout these periods, the comparison becomes direct, and this is the case with the Erian and Carboniferous floras in North-Eastern America. But when the areas of the two formations are widely separated in space, as well as in time, any resemblances of facies that we may observe may have no connection whatever with an unbroken continuity of specific types.

I desire, however, under this head, to affirm my conviction that, with reference to the Erian and Carboniferous floras of North America and of Europe, the doctrine of "homotaxis," as distinct from actual contemporaneity, has no place. The succession of formations in the Paleozoic period evidences a similar series of physical phenomena on the grandest scale throughout the northern hemisphere. The succession of marine animals implies the continuity of the sea-bottoms on which they lived. The head-quarters of the Erian flora in America and Europe must have been in connected or adjoining areas in the North

Atlantic. The similarity of the Carboniferous flora on the two sides of the Atlantic, and the great number of identical species, proves a still closer connection in that period. These coincidences are too extensive and too frequently repeated to be the result of any accident of similar sequence at different times, and this more especially as they extend to the more minute differences in the features of each period, as, for instance, the floras of the Lower and Upper Devonian, and of the Lower, Middle, and Upper Carboniferous.

Another geographical question is that which relates to centers of dispersion. In times of slow subsidence of extensive areas, the plants inhabiting such areas must be narrowed in their range and often separated from each other in detached spots, while, at the same time, important climatal changes must also occur. On the re-emergence of the land, such of these species as remained would again extend themselves over their former areas of distribution, in so far as the new climatal and other conditions would permit. We should naturally suppose that the first of the above processes would tend to the elimination of varieties, the second to their increase; but, on the other hand, the breaking up of a continental flora into that of distinct islets, and the crowding together of many forms, might be a process fertile in the production of some varieties, if fatal to others.

Further, it is possible that these changes of subsidence may have some connection with the introduction, as well as with the extinction, even of specific types. It is certain, at least, in the case of land plants, that such types come in most abundantly immediately after elevation, though they are most abundantly preserved in periods of slow subsidence. I do not mean, however, that this connection is one of cause and effect; there are, indeed, indications that it is not so. One of these is, that in some cases the enlargement of the area of the land seems to be as injurious to terrestrial species as its diminution.

Applying the above considerations to the Erian and Carboniferous floras of North America, we obtain some data which may guide us in arriving at general conclusions. The Erian flora is comparatively poor, and its types are in the main similar to those of the Carboniferous. Of these types a few only re-appear in the Middle Coal formation under identical forms; a great number appear under allied forms; some altogether disappear. The Erian flora of New Brunswick and Maine occurs side by side with the Carboniferous of the same region; so does the Erian of New York and Pennsylvania with the Carboniferous of those States. Thus we have data for the comparison of successive floras in the same region. In the Canadian region we have, indeed, in direct sequence, the floras of the Upper Silurian, the Lower, Middle, and Upper Erian, and the Lower,

Middle, and Upper Carboniferous, all more or less distinct from each other, and affording an admirable series for comparison in a region whose geographical features are very broadly marked. All these floras are composed in great part of similar types, and probably do not indicate very dissimilar general physical conditions, but they are separated from each other by the great subsidences of the Corniferous limestone and the Lower Carboniferous limestone, and by the local but intense subterranean action which has altered and disturbed the Erian beds toward the close of that period. Still none of these changes was universal. The Corniferous limestone is absent in Gaspé, and probably in New Brunswick, where, consequently, the Erian flora could continue undisturbed during that long period. The Carboniferous limestone is absent from the slopes of the Appalachians in Pennsylvania, where a retreat may have been afforded to the Upper Erian and Lower Carboniferous floras. The disturbances at the close of the Erian were limited to those eastern regions where the great limestone-producing subsidences were unfelt, and, on the other hand, are absent in Ohio, where the subsidences and marine conditions were almost at a maximum.

Bearing in mind these peculiarities of the area in question, we may now group in a tabular form the distinct specific types recognized in the Erian system, indicating, at the same time, those which are represented by identical species in the Carboniferous, those represented by similar species of the same general type, and those not represented at all. For example, *Calamites cannæformis* extends as a species into the Carboniferous; *Asterophyllites latifolius* does not so extend, but is represented by closely allied species of the same type; *Prototaxites* disappears altogether before we reach the Carboniferous.

Of the accompanying forms, fifty-one in all, found in the Erian of Eastern America, all, except the four last, are certainly distinct specific types. Of these only four reappear in the Carboniferous under identical species, but no less than twenty-six reappear under representative or allied forms, some at least of which a derivationist might claim as modified descendants. On the other hand, nearly one half of the Devonian types are unknown in the Carboniferous, while there remain a very large number of Carboniferous types not accounted for by anything known in the Devonian. Further, a very poor flora, including only two or three types, is the predecessor of the Erian flora in the Upper Silurian, and the flora again becomes poor in the Upper Devonian and Lower Carboniferous. Every new species discovered must more or less modify the above statements, and the whole Erian flora of America, as well as the Carboniferous, requires a thorough comparison with that of Europe before general conclusions can be safely drawn. In the meantime I may indicate the

Table of Erian and Carboniferous Specific Types.

Erian Types. Represented in Carboniferous—	by identical types.	by relat'd forms.	Erian Types. Represented in Carboniferous—	by identical types.	by relat'd forms.
1. Syringoxylon mirabile,			27. Cordaites Robbii,		*
2. Nematoxylon,			28. C. augustifolia,		
3. Prototaxites,			29. Cyclopteris (Archæopteris),		
4. Aporoxylon,			30. C. (Aneimites),		*
5. Ormoxylon,			31. C. Brownii,		
6. Dadoxylon,		*	32. C. varia,		*
7. Sigillaria Vanuxemii,		*	33. Neuropteris polymorpha,		*
8. S. palpebra,		*	34. N. Serrulata,		*
9. Didymophyllum,			35. N. Dawsonii,		
10. Calamodendron,		*	36. N. retorquata,		*
11. Calamites transitionis,	*		37. N. resecta,		
12. C. cannæformis,	*		38. Spenopteris Hœninghausi,	*	
13. Asterophyllites scutigera,			39. S. Harttii,		*
14. A. latifolia,		*	40. Hymenophyllites curtilobus,		
15. Annularia laxa,			41. H. obtusilobus,		*
16. Sphenophyllum antiquam,		*	42. Alethopteris discrepans,		*
17. Cyclostigma,			43. Pecopteris serrulata,		*
18. Arthrostigma,			44. P. preciosa,		
19. Lepidodendron Gaspianum,		*	45. Trichomanites,		*
20. L. Veltheimianum,		*	46. Callipteris,		*
21. Lycopodites Matthewi,		*	47. Psaronius,		*
22. L. Richardsoni,			48. Cardiocarpum,		*
23. L. Vanuxemii,			49. C. Crampii,		
24. Lepidophloios antiquus,		*	50. Antholithes,		*
25. Psilophyton princeps,			51. Trigonocarpum,		*
26. P. robustius,					

direction in which the facts seem to point, by the following general statements:—

1. Some of the forms reckoned as specific in the Devonian and Carboniferous may be really derivative races. There are indications that such races may have originated in one or more of the following ways:—(1) By a natural tendency in synthetic types to become specialized in the direction of one or other of their constituent elements. In this way such plants as *Arthrostigma* and *Psilophyton* may have assumed new varietal forms. (2) By embryonic retardation or acceleration,† whereby certain species may have had their maturity advanced or postponed, thus giving them various grades of perfection in reproduction and complexity of structure. The fact that so many Erian and Carboniferous plants seem to be on the confines of our groups of Acrogens and Gymnosperms may be supposed favorable to such exchanges. (3) The contraction and breaking up of floras, as occurred in the Middle Erian and Lower Carboniferous, may have been eminently favorable to the production of such varietal forms as would result from what has been called the "struggle for existence." (4) The elevation of a great expanse of new land at the close of the Middle Erian and the beginning

† In the manner illustrated by Hyatt and Cope.

of the Coal period, would, by permitting the extension of species over wide areas and fertile soils, and by removing the pressure previously existing, be eminently favorable to the production of new, and especially of improved, varieties.

2. Whatever importance we may attach to the above supposed causes of change, we still require to account for the origin of our specific types. This may forever elude our observation, but we may at least hope to ascertain the external conditions favorable to their production. In order to attain even to this it will be necessary to inquire critically, with reference to every acknowledged species, what its claims to distinctness are, so that we may be enabled to distinguish specific types from mere varieties. Having attained to some certainty in this, we may be prepared to inquire whether the conditions favorable to the appearance of new varieties were also those favorable to the creation of new types, or the reverse—whether these conditions were those of compression or expansion, or to what extent the appearance of new types may be independent of any external conditions, other than those absolutely necessary for their existence. I am not without hope that the further study of fossil plants may enable us thus to approach to a comprehension of the laws of the creation, as distinguished from those of the continued existence of species.

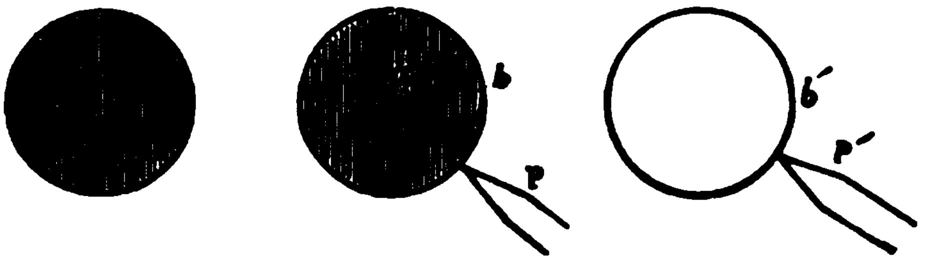
In the present state of our knowledge we have no good ground either to limit the number of specific types beyond what a fair study of our material may warrant, or to infer that such primitive types must necessarily have been of low grade, or that progress in varietal forms has always been upward. The occurrence of such an advanced and specialized type as that of *Syringoxylon*, in the Middle Devonian, should guard us against these errors. The creative process may have been applicable to the highest as well as to the lowest forms, and subsequent deviations must have included degradation as well as elevation. I can conceive nothing more unreasonable than the statement sometimes made that it is illogical or even absurd to suppose that highly organized beings could have been produced except by derivation from previously existing organisms. This is begging the whole question at issue, depriving science of a noble department of inquiry on which it has as yet barely entered, and anticipating by unwarranted assertions conclusions which may perhaps suddenly dawn upon us through the inspiration of some great intellect, or may for generations to come baffle the united exertions of all the earnest promoters of natural science. Our present attitude should not be that of dogmatists, but that of patient workers content to labor for a harvest of grand generalizations which may not come till we have passed away, but which, if we are earnest and true to nature and its Creator, may reward even some of us.

ART. LIII.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE, Prof. Geol. and Nat. Hist., University of California.

In giving my own explanation of the phenomena of M. Pictet's experiments, I will commence with the experiment with the piece of money. If M. Pictet had made this experiment *without* the median screen, it seems to me the true explanation could not have escaped him. Let us then first try it without the screen.

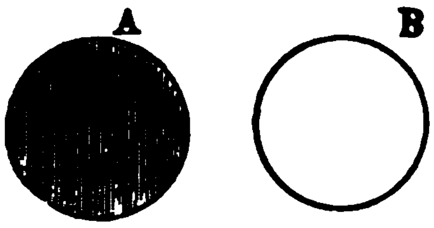
If I place a piece of money on a sheet of paper lying on the table, and look downward in the direction of the piece, but at the same time gaze on vacancy, I see two heteronymous images,

8.



a a' (fig. 8), separated by an interocular space. If I now attempt to outline these images, I see also *two images of the pencil.* If I use the *right-eye image* (left image) of the pencil *p* to draw the *left-eye image* (right image) of the money *a'*, then I see one pencil tracing the outline *b* of the image *a'*, while another pencil makes a tracing *b'* with no money in it. If I now examine the result of this experiment, I find the tracing I have made, B (fig. 9), at

9.



some distance (an interocular space) from the piece A to the right. The explanation is obvious. In gazing on vacancy, as already explained (2), the whole field of view is shifted by each eye heteronymously a half interocular space. The left-eye image of A (fig. 9) and the right-eye image of the spot B are brought together and superposed (*a' b*, fig. 8); while the right-eye image of A and the left-eye image of B are seen to the left and right respectively (*a* and *b'*, fig. 8). It is precisely the same as the superposition of the double images of two fingers described on page 165. If, instead of using the right image of the pencil to draw the left-eye image of the money, I use *corresponding images* of the pencil and money, i. e., right-eye images or left-eye images of both, I find *I place the pencil on the money.* Finally, if I use the left-eye image *p'*, fig. 8, of the pencil to draw the right-eye image *a* of the money, I find I have made a tracing *an interocular distance to the left*, and the result of both experiments is two tracings a double interocular distance apart.

Now in M. Pictet's mode of performing the experiment, by the use of the median screen, we cut off the right-eye image of the money *a*, fig. 8, and the left-eye image of the pencil *p'*, fig. 8, and we therefore see only the left-eye image of the money *a'*

together by the law of corresponding points. In M. Pictet's experiment these two, the pencil and the money, are similarly related to the two eyes, one on one side and the other on the other side of the screen—one exposed to the view of one eye and the other to the view of the other eye. If the image we draw is an illusive image seen by the right eye, then the *pencil* with which we draw must be also an illusive image seen by the left eye.

But to explain M. Pictet's experiment a little farther: When we look *directly at the money*, M. Pictet says "we see that the vertical screen is transparent throughout, and that it permits the right eye to see the piece as through a perfectly diaphanous surface." But there are *two* transparent screens seen. The one seen by the right eye M. Pictet observes,* the other apparently escapes his observation. The truth is, when we look at the money, the heteronymously doubled images of the median screen $m\ m'$ (fig. 14) meet at the distance of the point of sight. The actual relation of parts is seen in fig. 7 (p. 322), in which A R and A L are the visual lines converged upon the piece A. The visual result is seen in fig. 14. It is seen that the visual line of the right eye stops at the right eye image of the median screen, while the left visual line runs parallel to its image of the median screen unobstructed to the piece a'. Again, "if we give to the optic axes a direction more parallel," says M. Pictet, "we see the image of illusion move gradually to the right, traverse the screen, and come on the right side." But again, he does not observe that there are two screens seen; and again, it is the left eye image of the screen which he neglects. In truth, as the eyes become parallel, the two images of the screen, m S and m' S' fig. 14, gradually open until they become parallel, and the piece is seen between them, as already shown in fig. 13. The *piece does not in the least change its position in relation to the creen seen by the left eye;* only the right eye *shifts its image of the creen* to the left of it. If M. Pictet would place another piece of money on the right side of the screen exactly where he made he outline tracing, he would observe the two pieces unite in one, precisely as stereoscopic pictures are united. According o M. Pictet's principles, this must be regarded as the *union of two illusive images.* Where, then, are the real images?

14.

* There seems to be a kind of *dexterity* in the right eye. In many cases of double images, most persons habitually neglect the left-eye image.

It is now easily understood that by the use of lenses before the *right eye*, in M. Pictet's experiments, the image is not affected, not because it is *illusive*, but because it is the image of the *left eye*. But if the experiment be made *without* the median screen, then the true right-eye image *a*, fig. 8, will be seen to the left and *will* be enlarged. The explanation of the outlining of objects seen under the microscope is, of course, precisely the same, as is also that of the tracing on the blank half of a stereoscopic card the outline of a picture existing on the other half.

I might illustrate the subject farther in many ways, but it seems scarcely necessary. I will only remark, in passing, that by the movement of the fields of view already explained (8), it is easy, by voluntary squinting, to outline a piece of money, *in any part* of a sheet of paper one may desire. I now place a piece of money on a sheet of paper lying on the table; I place the pencil on any point where I desire to make the outline; it may be 4, 6, 10 or 12 inches from the piece. By squinting, I now bring together the right-eye image of the piece and the left-eye image of the pencil, and then trace the outline. It is a little difficult, it is true, without some small object at the point of optic convergence (point of sight) to hold the axes steady, and, therefore, to make the tracing accurate. I only speak of it to illustrate the principle of making tracings of objects at any distance from the object itself. In the case of squinting, of course a median screen is inadmissible.

The phenomena of M. Pictet's first experiment, fig. 6, will now be easily understood. If *no median* screen is used, then fig. 15 will represent the actual relation of parts, and fig. 16 the visual result. By comparing these two figures, it will be seen that the two visual lines *v v* are brought together, so that the left-eye image of A, and the right-eye images of the spot *b* and the pencil P, fig. 15, are brought in the same line in fig. 16; but the left-eye images of the spot *b* and of the pencil

15.

16.

, fig. 15, are seen to the right b' P′, fig. 16. If we attempt to se P′ instead of P to make the outline, we would miss the reen. Now in M. Pictet's experiment *with* the median screen g. 6, this screen cuts off the left-eye image of the spot *b* and of the pencil P, so that we have only the left-eye image of the object A, and the right-eye image of the spot *b*; and these, by the law of corresponding points, are brought in the same line. The visual result is represented in fig. 17.

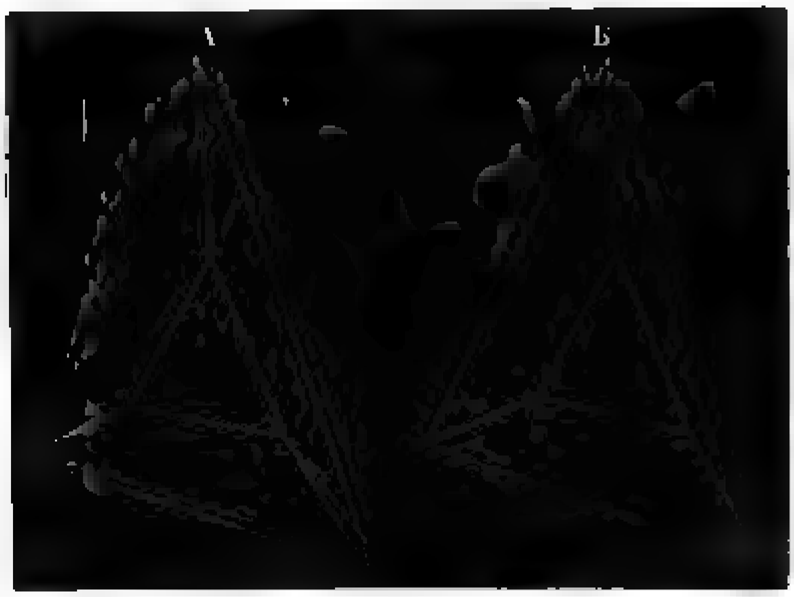
17.

As illustrating the singular confusion into which M. Pictet has fallen, I would draw attention to the fact, that in his experiments on the transparency of double images, described on page 8, as well as in the experiment last explained, the *double images* are regarded as *real*, while the *objects*, seen beyond as through a transparency, are regarded as *illusive*. But in the experiment with the piece of money, it is one of the *double images* which he regards as illusive.

It is unnecessary to follow M. Pictet through l his experiments, as the same principles of explanation apply all. There is one more point, however, which I wish to take p at some length. It is the *theory of binocular relief*. I wish show the fallacy of M. Pictet's views, and at the same time bring out more distinctly than I have ever yet done my own iews on this important subject.

M. Pictet believes that, in every act of binocular vision, there re *four external images* formed; that *each eye* has its own *real* nage, produced by the luminous retinal image, and its *illusive* nage, propagated from the luminous impression of the other eye, nd identical with the real image of the latter; that, as the two eal images differ slightly from each other, being taken from ifferent points of view, so do their fac-similes the two illusive nages; also, necessarily, that the real and illusive images of ach eye differ precisely, as do the two real images or the two lusive images. He believes that *the perception of relief is the esult of comparison by each eye of its real with its illusive image.* Iow what advantage this theory has over the usual and simpler ne of Brewster, Prevost and Brücke, considering the fact that he real and illusive image of each eye differ precisely as do he real images of the two eyes, it is impossible to imagine. But M. Pictet regards the existence of the four images not as a uestion of advantage, but as a question of fact. "A very imple geometric construction shows us thus four images identical, two to two." I reproduce M. Pictet's figure illustrating

this point. The full-lined figs. A and B are two projections of a truncated pyramid, as seen by the left and right eye respectively.



On the same smaller or upper base, two dotted-lined figures are drawn in such wise, that each dotted-lined figure is exactly similar to the other full-lined figure. These four figures, according to M. Pictet, represent accurately the *four images* formed in looking at a *single* truncated pyramid, the full-lined figures being the true and the dotted-lined figures the illusive images. For, says he, "if we unite in one single image these four contours (by means of a stereoscope), we experience instantly the impression of a solid body; and we see that in fact the dotted lines are covered by the full lines in the binocular image, *which confirms our deduction*" (p. 141).

Now, according to the usual theory of binocular relief, viz., that of Brücke, Prevost and Brewster, how could it be otherwise? By construction, each dotted-lined figure is the fac-simile in form of the other full-lined figure, so that when their common faces, the small triangles, are united, the full-lines of the one figure *must* coincide with the dotted lines of the other. M. Pictet has therefore, by his dotted lines, only represented in *each* of his figures what must take place in the *binocular combination of his two full-lined figures*, if there were no dotted lines present; viz., the doubling of the lines of the larger triangles or lower bases, when the small triangles or upper bases are perfectly united; a fact well known to every accurate observer, and which forms the foundation of Brücke's theory.

Brücke, Prevost and Brewster explain the perception of relief by rapid changes of optic convergence, by means of which different parts of the two dissimilar images of the same object, or of two stereoscopic pictures, are successively united. In M. Pictet's full-lined figures, for example, when the smaller triangles are united, the lines of the larger triangles are slightly doubled; and when, by less optic convergence, the larger triangles are perfectly united, then the smaller triangles are doubled. Thus, the alternately greater and less convergence, necessary to unite successively different parts of the pictures—the ranging of the point of sight back and forth—precisely

like that which takes place, in natural vision, in looking successively at nearer and more distant objects, or nearer and more distant parts of the same object, gives a distinct perception of relief.

No one who has carefully analyzed his visual impressions, either in natural vision or in stereoscopic combination of pictures, can for a moment doubt that there is in all cases *a change of optic convergence* necessary to unite the different portions of a stereoscopic picture or of a natural solid object; and that Wheatstone's idea of a *complete mental combination* of dissimilar images, though still supported by great names, is certainly erroneous. In my own case, the doubling of objects in the foreground of stereoscopic pictures, while I look at the background and *vice versa*, is as plain as any other phenomenon of vision. It is impossible for me to doubt what I see so plainly. Precisely similar phenomena I detect with ease in viewing solid objects. Brücke and Prevost are therefore certainly *right* in insisting, against Wheatstone, on the *impossibility of complete union* of all parts of a stereoscopic picture of an object at the same moment; but they are, I believe, as certainly *wrong* in insisting *on changes of optic convergence* as absolutely *necessary to the perception of relief.* It is possible to perceive relief—even *while looking steadily at one point* in a stereoscopic or in a natural scene. Dove's much quoted experiment seems to prove that we can distinctly perceive stereoscopic relief by the light of an electric spark, which according to Wheatstone's celebrated experiment lasts only $\frac{1}{24000}$ of a second; a time too short to allow *change* of optic convergence. The relative distance of objects, I think, without doubt, can be distinctly perceived by the light of a flash of lightning, which according to Arago lasts less than $\frac{1}{1000}$,* and according to Rood $\frac{1}{500}$† of a second. These facts seem to prove that stereoscopic relief can be perceived *instantly* and *without change of optic convergence.*

This point is evidently one of capital importance in the theory of binocular vision. The *instantaneous* perception of relief is evidently *fatal to Brücke's theory.* With the assistance of my brother, Prof. John LeConte, I have, therefore, recently made a series of experiments to test its correctness. These experiments entirely confirm Dove's results, and establish beyond doubt the instantaneous perception of relief.

The apparatus used in these experiments was a first-class Ritchie's induction coil, capable of producing with ease 12-inch sparks. The contact-breaker was of such kind that the rapidity of the sparks was completely under the control of

* Arago, Œuvres complete, tome 4, p. 70. † This Jour., III, vol. i, p. 15.

the operator. A Leyden jar was introduced into the circuit in order to increase the brilliancy of the sparks. The sparks were 1–2 inches in length. I selected stereoscopic pictures in which all *other* forms of perspective were entirely wanting, so that *no relief was visible with one eye.* Outline geometrical figures are best for this purpose.

I first viewed these in the stereoscope by the continuous light of a rapid succession of sparks, until the stereoscopic combination was perfect. On making the sparks separately at long intervals, the *relief was still perfectly clear* and unmistakable. On shutting one eye, the sparks continuing at intervals, the relief disappeared; on re-opening, it immediately re-appeared.

I next tried combination of the pictures with *the naked eye by squinting.* This method is entirely removed from any suspicion of fallacy arising from any other kind of perspective; since, as already stated in my previous paper,* the binocular perspective is *inverted*, and therefore, must overbear all other forms of perspective where these exist. By a rapid succession of sparks, the combination was easy and the inverse perspective perfect. When the sparks were made with long intervals between, *still the relief was clear* and unmistakable. Shutting one eye the relief disappeared, but immediately reappeared on re-opening.

When I first commenced my experiments by either of these methods, but especially the last, a rapid succession of sparks was necessary to effect combination. After the proper axial adjustment was once obtained, it could be retained without difficulty in the interval of darkness. After some practice however, the rapid succession of sparks was no longer necessary. The combination was effected, and the relief perceived by *separate flashes alone.*

Lastly, I tried natural vision. Two small objects, (brass balls mounted on wires) were placed one beyond the other at the distance of five or six feet, and separated from each by a space of about 1 foot; sometimes in the median line, and sometimes one of them a little out of the median line, but in all cases so arranged *that their relative distance could not be detected by monocular vision*, even in the full light of day. By the spark their relative distance was *at once detectable with two eyes*, though *not with one.* This last experiment was varied in many ways, but always with the same result.

Stereoscopic combination by squinting requires considerable practice, even in the full light of day, and of course much more by the electric spark. All the *other* experiments were repeated by my brother, and my results confirmed.

* III, vol. ii, p. 1.

M. Pictet *rightly* urges Dove's experiment on the instantaneous perception of relief as fatal to Brücke's theory, but *wrongly* as confirming his own. The objection applies equally to both. In both cases there is a judgment formed from a comparison of dissimilar images or pictures, and it can make no difference whether the images are real or illusive, or whether one be real and one illusive, since the illusive image behaves in all respects and under all circumstances, precisely like the real image of the other eye.

The only *true* explanation of the instantaneous perception of relief is, I believe, that given in my paper recently published.* As already stated (3), all objects or points, either beyond or on this side the point of sight, are doubled, but differently, the former *homonymously* the latter *heteronymously*; the double images of the former are united by *less*, the latter by *greater convergence.* Now the observer *knows instinctively and without trial*, in any case of double images, *whether they will be united by greater or less convergence;* and therefore, never makes a mistake nor attempts to unite by a wrong movement of the optic axis. In other words *the eye instinctively distinguishes between homonymous and heteronymous images, referring the former to objects or points beyond, and the latter to objects or points on this side, the point of sight.* My own theory of stereoscopic relief, then, is this: The eye perceives relief *instantly*, by means of double images, as just explained; but the perception is made much clearer by *changes* of optic convergences, by ranging the eyes back and forth from foreground to background and *vice versa*, and the successive combination of different parts of the object or pictures, as maintained by Brücke.

In regard to the relative merits of the nativistic and empiristic theories, i. e., whether corresponding points are such congenitally or become so by experience, I quite agree with Donders, that there is truth in both views. In a letter to Prof. Tyndall, published in the Phil. Mag. for April, 1871, referring to the question whether the "*law of direction*" was native or acquired, I have said that instinct is nothing but "*inherited experience.*"† Precisely the same remark applies to the law of corresponding points. *It is acquired by the experience of successive generations transmitted by the law of inheritance, and made more perfect by individual experience.* The inherited experience is greater in the lower animals, the individual experience is greater in man. Binocular single vision is therefore, to a large extent, instinctive even in man, and much more so in lower animals. Doubtless, this is equivalent to saying that there is some *structural arrangement* in the nervous centers which deter-

* This Jour., III, vol. ii, p. 1, et seq.

† I had not then seen the similar view of Hering, viz., that instinct is "inherited memory."

mines single vision by corresponding points; but whether there is any such *fusion* of corresponding fibres as supposed by Müller, or any such reflection of illusive images from eye to eye as supposed by M. Pictet, can never by determined except by anatomical investigation; and even if so determined in the affirmative, could not possibly show itself in any visual phenomenon, since by supposition every such *illusive* image must be absolutely identical with, and absolutely inseparable from, a *real* image seen by the other eye.

Oakland, California, June 9, 1871.

Art. LIV.—*The American Spongilla, a craspedote, flagellate Infusorian*; by H. James-Clark, A. B., B. S., Prof. Nat. Hist., Kentucky University, Lexington, Ky. (With a Plate).

The argument of Hæckel, and others, that the Sponges are essentially compound Polypi, is virtually based upon the assumption that the minor (afferent) and major (efferent) ostioles of the former correspond to the mouths of the latter; and that the profusely branching afferent and efferent canals of the Sponges are strictly comparable with similar canals in the polypidom of Halcyonarians; and, by implication, that the cilia-bearing cells of the interior, lining-wall of the Zoöphyte find their homologues in the ciliated, cell-like bodies of the interior chambers of the Porifera. If, now, it should turn out that these last are not altogether mere cell-components of a tissue, but are each, severally, an independent body, although closely connected with others in a common bond, then the attempted parallelism between the two groups must utterly fail of confirmation. The tendency of Carter's later investigations, and our own too, is to show that this is no vain supposition.

For ourselves, we hold that each *ciliated body* of the Sponge is a *cephalic* member (a *cephalid* in this case) of a polycephalic individual.* We believe, as far as we can understand his undecided, rather hesitating position, Carter's latest decision is that the Sponge is a community of Amœbous individuals,† and not a polycephalic unit. Yet, whichever view prevails, the tendency is the same, and the Polyp theory is negatived most unquestionably. The incompatibility of the interior organisms of the two groups, above mentioned, is so great that it would seem as idle to elaborate a proof of it, as to attempt the demonstration of an axiom. The question is really circumscribed.

* See our article on "*Polarity and Polycephalism*," this Journal, January, 1870.

† See Carter, *On Fecundation in the two Volvoces; on Eudorina, Spongilla, &c.* Annals and Magazine Nat. Hist., January, 1859; also for July, 1871, *On sea Sponges*, &c.

according to the method of Hæckel, to arguing that, since a system of branching canals in the Sponge reminds one very strongly of the intricate network of passage-ways in the basal parts of certain Polyps, therefore the two are homologous, and bear an identical relation to the rest of the organism. Carter (*On new Sponges, &c.*, Ann. Mag. Nat. Hist., July, 1871) has answered this far-fetched homology with considerable detail in a recent paper; and we do not, therefore, feel called upon to add more to it.

The principal aim of this article is to furnish new material in proof of the polycephalism of the Spongiæ, and particularly in regard to their relation with the *Protozoa Flagellata.* We are highly pleased to find that Carter has lately (ut sup., July, 1871) confirmed our earliest observations* as to the organization of the collar-bearing monads of *Leucoselenia*, by an investigation of *Grantia compressa.* He has also accepted our interpretation of the horn-like processes of the sponge-cell of *Spongilla alba;* that they are the outlines of a membraneous collar in profile.

We have now to bring forward a fourth example of a *craspedote*, flagellate monad-cephalid in a Sponge. It seems to be a *Spongilla*, but specifically, at least in its monads, it differs from the English forms. For convenience sake, we will call it *Spongilla arachnoidea*, from its resemblance to an irregular spider-web. It lives in fresh water streams and ponds, usually about the bottom of the stems of water-plants, or wherever there is considerable shade; apparently avoiding the light, as we seldom, if ever, found it in open water. In size it varies from a few inches to half a line in diameter; of no definite shape; and has a uniform fuscous or yellowish-brown color; and is wrapped about by a filmy, transparent, colorless envelope ("*investing membrane*" Carter). The brown color is inherent to the interior mass, in which the groups of monads are imbedded; in fact the latter are themselves as strongly colored by brown granular contents. The "investing membrane" is also slightly tinged with amber color by the large and small spicules which are imbedded in it. Excepting in very small specimens, foreign matter is often so thickly spread over the surface as to obscure the view and seriously interfere with a correct interpretation of the relation of parts. We have been most fortunate in our endeavors with the minuter individuals, which occasionally, we found, would allow a view through and through their entire bulk, and of course left full opportunity for a satisfactory study of the details of special parts, without our resorting to the dissecting needles. Anyone who knows, by experience, the intense contractility of the living sponge, can appreciate the ad-

* Memoirs Boston Soc. Nat. Hist., vol. i, 1867, "*On the Spongiæ Ciliatæ as Infusoria Flagellata.*"

vantage of not being obliged to destroy and sever parts of an organism from their natural relations. Premising thus, that everything has been studied "in place," even to the details of the monads, we shall endeavor to describe this sponge as if it were to be the type for future comparison.

General plan.—The whole individual sponge is endowed with a double envelope (fig. 1 *a*,a^1, *c*, *d*,) the outer and inner parts of which are directly continuous into each other at many points. The outer division (*a*, a^1) lies at a considerable distance from the monadigerous mass (*g*), and is, as it were, suspended on the points of the larger, far-projecting spicules (*e*); just as a tent canvas is supported on the ends of poles. The inner division (*c*) closely embraces the monadigerous mass like an epidermis, and even plunges between the hollow groups of monads, forming to them a basis of support. The outer and inner divisions are continuous with each other at many points, as stated just now, but only where the larger spicules project. There the envelope (*d*) runs along the spicules, completely embracing them, as if in a sheath, from their tips to their bases, where they rest on the brown mass of monads. In brief, we might say that the sponge is covered with a miniature colonnade, whose ceiling is the outer division of the envelope, the pillars are the bundles of spicules, and the floor is tapestried by the inner division, which about the pillars hangs from the ceiling in lofty folds. The continuity of the outer division of the envelope is broken by numerous, round or oval openings, of various and frequently changing sizes, sometimes very large, which allow a free ingress of the water to the space just beneath. These are the *afferent ostioles* (*os*), through and into which a constant current of floating particles may be seen moving with considerable vivacity. Here and there, scattered at wide distances, finger-like, hollow processes from the outer division arise singly, and at various angles. Each is terminated by a large aperture, the *efferent ostiole*, from which a current of water and floating matter emerges with more or less spasmodic irregularity. The smaller individuals, from half a line to half an inch in diameter, possess only one such ostiole; and those an inch in diameter seldom have more than two or three like conduits; but they are very large, sometimes a quarter of an inch in length when fully extended, and of the proportions and taper of the human forefinger.

Plunging the focus of the objective to the floor of the colonnade, the inner division (*c*) there is found to be pierced by much more numerous openings (*i*), but far smaller in diameter, and quite methodically arranged, each one corresponding to and overlying a hollow group of monads (*h*). The outer division is further embellished with irregularly scattered minute

spicules (e^1), which lie imbedded in the cytoblastema, parallel with the surface of the envelope, and occasionally crossing each other at various angles. To complete this general sketch, we will state more definitely the relation of the constituents of the monadigerous mass. There are essentially but two elements here; namely, the inner division (c) of the investing membrane, and the groups of monads (h) which are imbedded in it, below its surface. In a fully expanded individual these groups seldom lie so closely as to touch each other. They vary considerably in size and are usually globular or spheroidal, and form a single *stratum*, with rather narrow interspaces (c^1) between them.

It seems proper here, at least for the sake of precision, that the *cytoblastematous basis*, in which the monad groups are imbedded, should be considered apart from the epithelium-like, inner (c) investing membrane which overlies it, although the two are essentially one; the epithelioid membrane, by prolonging itself between (at c^1) and beneath the groups, forming for them a continuous foundation. In this light, then, we shall speak of the monadigerous mass as consisting of three elements, namely, the inner investing membrane proper, the group of monads, and the *cytoblastematous basis*. This *basis* seems to constitute a large part of the bulk of the body, since it occupies all of the interior space beneath the monad groups. In specimens which grow over flat surfaces in depressed patches, or around stems of plants, it forms a relatively thin layer; but where the body stands out an irregularly rounded mass, sometimes an inch in diameter, the cytoblastematous basis fills up the interior, in enormous proportion to the bulk of the monad layer.

ORGANOGRAPHY.

The Investing Membrane.—The *investing membrane* (fig. 1, a, a^1, c, d,) consists essentially of two histiological elements, namely, a very diffuse *cytoblastema* (a^1) and irregularly disposed cells (b, b^1, b^2) scattered through it. The intercellular *cytoblastema* forms a very thin layer (a^1) between the cells (b); but where the latter are imbedded in it, its outer and inner faces are as wide apart as the considerable depth of the cells demand; and thus it happens that the membrane (both the outer and the inner divisions) presents in profile (a^1, c, d) such an irregular thickness. The *cytoblastema* (a^1) is colorless, hyaline, and apparently homogeneous under a low power; but, when magnified to about four hundred diameters, it displays a very finely granular aspect. It occupies wide intervals between the cells, certainly more than one-half, and fully three-fifths of the whole area of the membrane. Its apparent extent, in a general view, is even more

than that, owing to the extreme transparency of the cells, and their consequent inconspicuousness. That the cytoblastema, notwithstanding its low undeveloped state, is the true contractile element in this membrane, there can scarcely be a doubt, when we consider both its wide spread preponderance, and its relative continuity, as contrasted with the scattered, disconnected condition of the cells (b^2) which are imbedded in it. Sometimes it is barely possible to discover even the trace of a cell on the border of an afferent ostiole (*os*), and in that case we must infer, inevitably, that it is cytoblastema which opens and closes the aperture. We find it, too, embracing the extreme tips of the larger spiculæ, where the cells utterly fail to appear.

The *cell-element* (*b*) of this membrane is also in a lowly condition; only partially developed. There is no *cell-wall*. What may appear to be a wall is really the thin stratum of cytoblastema (a^1) overlying the distal and proximal faces of the cell. This is our conclusion after the most critical scrutiny, with a carefully-corrected objective. Were it not, indeed, for the usually constant presence of a distinct nucleus (*n*) in each cell, we would be strongly inclined to look upon it as merely a dense collection of coarser granules than are generally diffused through the cytoblastemic layer. The irregular and jagged outline, and the caudate projections of the cells (b^2) also tend to tempt one to the latter view. The cell element in this case, then, corresponds only to what is usually considered the cell contents, and a nucleus. The contents are composed of coarse and fine grey granules, which at times are quite conspicuous, but most frequently are so transparent and slightly refractive as to appear, collectively, unless specially focussed upon, as a faint blotch in the investing membrane. This renders it all the more difficult to trace the outline of the cell, and particularly where it throws out irregular, caudate prolongations, to blend with those of other cells. We have been able to detect but one layer of cells in this membrane* when it is well stretched out. The depth of the cells, as may be seen in a sectional profile view (*b*), is about equal to their breadth, and their length is from one-half more than to twice their breadth; but frequently they are as broad as long. They stand in no particular relation to the ostioles; and, as stated above, sometimes scarcely touch their border. The *nucleus* (*n*) may be readily detected by its peculiar, strong refraction, and its considerable superiority in size over the granules. Its bright refractiveness in this connection reminded us of a contractile vesicle, but, although suspecting it of such a function, we could detect no change other than might be produced by the varying length and breadth of the cell, and the

* Carter figures two or three cells overlying each other in *Spongilla alba*. Ann. Mag. Nat. Hist., July, 1857, Pl. 1, fig. 7.

shifting of the relative position of the coarse granules. In the *inner division* (*c*) of the investing membrane the cells are usually smaller than those in the outer division, but differ in no respect, otherwise, neither in form nor arrangement. They lie flat on their sides in the cytoblastemous layer; but, except in profile, they are most difficult to discover on account of the underlying brown mass of monad-groups and granular interstitial substance.

Although we have been unable to discover any distinct cell elements in the cytoblastematous mass immediately around and beneath the monad groups, neither have we found it possible to distinguish it from the cytoblastema lying on the surface; and since the continuity between the two is unbroken, we must, perforce, consider them as one. The underlying portion of the cytoblastematous mass, however, is characterized by irregularly scattered, moderately coarse, brown granules (c^1). These serve very well as a dark frame or setting to the monad-chambers (*h*), and by contrast brings them out more strongly.

The Monad-cephalids.—We now proceed to describe the most essential feature of this animal, the *monads.* They are the characterizing, the dominating element, in reference to which the whole organism is contrived and constructed. They are not cells; they are the *heads* of a polycephalic individual, and consequently correspond functionally to the tentaculated heads of Polypi, and not to their interior epithelial cells. We must first describe what we call the monad-chamber.

The *monad-chambers* (fig. 1, *h*; fig. 2; fig. 4) are deep, spherical hollows which form the receptacles of the groups of monads (*j*). They are mere cavities, and have no lining wall.* They may be easily recognized, in young specimens, as clear, more or less circular, areas scattered in pretty close proximity to each other over the "cytoblastemic mass." Each chamber has a single, small, circular aperture (*i*) which perforates the inner (*c*) investing membrane, and allows egress into the circulatory apartment (*f*). The aperture (*i*) varies in size at times, and may, even, be completely closed. We have never seen it open wider than one-third the diameter of the chamber, and very rarely more than one fifth as wide. That it is a true perforation, and not a clear spot, may be demonstrated by bringing a chamber into profile, so that its aperture (fig. 4, *i*) lies on the extreme border, and then an actual break in the continuity of the investing membrane becomes evident.

* The hollow groups of monads were originally described by Carter (Ann. Mag. Nat. Hist., July, 1857) as lining an hypothecated vesicle, which he named the "ampullaceous sac." He has since (Ann. Mag., Jan., 1859) revoked that view and adopted another. We believe him to be, excepting the inferred "ampullaceous sac," in the main, right in his first interpretation; but as our species are different we cannot speak definitely.

Entering this aperture we do not meet with any obstacle for a little distance around it; there is a clear open space (fig. 4); but pressing onward beyond that, either to the right or the left or directly forward, the cavity appears filled by a collection of vibrating bodies. They seem to be arranged radiatingly from and about the center. Close inspection, however, modifies this view, and it turns out that they are based upon the periphery of the chamber, and converge toward its center, where is a small unoccupied space. We presently recognize these converging bodies to be *craspedote*, *flagellate* monads (*j*), so closely packed together, side by side, as to form a continuous *stratum* (figs. 2 and 4) over the whole concave face of the chamber, excepting immediately about the aperture. Every feature of the monad is strongly marked; even the cylindrical collar is so heavy and conspicuous that its outlines may be seen with as low a power as two hundred diameters. We have studied these bodies with an $\frac{1}{8}$th-inch objective, and found it not at all difficult to focus down upon the details of their organization, without pressing upon or even touching the specimen.

These monads are in every general essential identical with those which we originally found in *Leucoselenia*, and like those, also, recently described by Carter (Ann. Mag. Nat. Hist., July, 1871), in *Grantia compressa*. They are attached to the concave face of the chamber by their posterior end (fig. 4, *j*); and the anterior extremity, with its flagellum (fig. 3, *l*) and collar (*k*), projects freely into the open space, and toward the center of the apartment. When fully expanded, the length of the body and collar together is about one-third, or a little more, of the diameter of the chamber; so that nearly one-third of the latter is unoccupied at the center, except by the tips of the flagella converging from every direction. As the monads lie touching each other on every side (fig. 2), they mutually flatten their bodies, sometimes so much as to give them a strong polygonal outline; or, when the whole mass is expanded, they scarcely impress each other, and therefore retain a rounded contour. By plunging the focus so as to look into the aperture of a chamber, down upon the monads at the bottom (fig. 2) of it, an end view of each cephalid is obtained. From this point the foreshortened cylindrical collar looks like a strong, dark circle (fig. 3ª, *k*), which retains its conspicuousness as we plunge down further, even to the base, where it is attached to the body (*j*). The outline of the latter is considerably without the "dark circle," the two being concentric to each other. At the same time we see in the center of the dark circle a black spot (*l*) which may, also, be focussed up and down upon, and hence it is inferred to be a continuous line foreshortened. Other views (fig. 3, *l*) confirm this, and show that it is a single *flagellum*.

The monads are so transparent, and the organization so distinct, that the collar and flagellum may be seen clearly from an opposite point of view, looking directly through the body of the cephalid. This, too, is the best position from which to study the *contractile vesicles.*

A sectional, profile view of a group (fig. 4), to be obtained by plunging the focus half way through a chamber, serves best to disclose the manner in which the posterior ends (*j*) of the monads are affixed to the concave face of their receptacle; and we, also, here obtain a strictly profile aspect of a monad. Figure 3 is such a view, representing a single cephalid, under a much higher power than in figures 2 or 4. An excellent and least obstructed side-view, but not strictly a profile, is to be had by focussing upon the monads immediately about the aperture of the chamber. Here we look directly into the door-way, or through the bordering, transparent epithelioid membrane which it penetrates.

The body, proper (fig. 3, *j*), of a cephalid is a little shorter than it is broad; on the whole spheroidal in shape. Its posterior end is broadly rounded, and so is its anterior extremity, In front arises a cylindrical, membranous "collar" (*k*), which tapers slightly and projects forward to a distance equal to considerable more than twice the length of the body. Its diameter is not more than two-thirds, or even less than that of the body. Although colorless, and homogeneous, it is remarkably conspicuous on account of the thickness of the membrane of which it is composed. Near its open extremity it is more transparent and less obvious than toward its basal attachment.

The *flagellum* (*l*) arises from the center of the anterior end of the body, in the midst of the area which is surrounded by the membranous cylinder (*k*), and without tapering extends a little farther than the open end of the latter. It vibrates usually throughout its length, but is most active near its tip. We have never seen it assume a rigid, arcuate position, as in some other species of monads. It is particularly remarkable for its want of transparency, and looks like a black thread more than any vibrating cilium that we have ever met with. Its action, at times, is rather that of a strong wriggle than a vibration.

The *contractile vesicles* (*v*).—The body of the monad is distinctly marked by a coarse, scattered, brown granulation, with two or three rather large, clear spots, at a considerable distance from each other, but always close to the periphery. These clear areas are the *contractile vesicles* (*v*). They do not occupy any particular place in the body, although they, usually, are not in front. The systole and diastole are extremely slow, but very distinct, if sufficient patience is summoned to watch them fixedly, and without interruption. The last third of the systole is

abrupt, and then only does the vesicle appear to contract suddenly; whereas by watching it through a complete circuit of diastole and systole, one learns that its function is, on the whole, performed very slowly. This very abrupt movement, quite happily, may serve to rebut any such objection as that the otherwise tardy action is merely the result of protoplasmic contraction of the body, as in certain Palmellate Zoöspores. Their immovable position, as regards the body contents, is another item of rebutting evidence.

The *Spiculæ* (fig. 1, *e*, *e*[1]) are very slender, slightly curved, needle-shaped bodies, gradually tapering to a sharp point at each end. They have a bright amber color, and a rather dark, strongly refractive outline. From tip to tip they are slightly roughened by irregularly scattered, low, but acute prominences or knobs. There are two kinds of spicules, large and small, but they differ in no other respect. The larger (*e*) are from four to six times longer and thicker than the smaller ones. They occur in bundles of two, three or four; and act as props to hold up the outer investing membrane, as described in the early part of this article. They seldom arise perpendicularly from the monadigerous mass, but more or less obliquely; and, in forming bundles, stand across each other like stacked arms. We seldom found spicules penetrating the monadigerous mass far beyond the epithelioid, inner investing membrane. They evidently belong, universally, to the investing membrane, and assist it in forming a framework in which the inner mass is suspended. The *smaller spicules* (*e*[1]) are strictly confined to the outer division (*a*) of the investing membrane, and lie there on their sides, completely immersed in its thickness. They are scattered irregularly and sparsely about, and frequently cross each other at varying angles. We observe no nearer approach to a methodical arrangement among either the large or the small spicules; yet their very irregularity, being after a kind, and constant in that kind, may be recognized in some sense as methodical.

General considerations.—Seeing the secluded position of the monad-cephalids, deeply ensconced in little chambers below the general surface of the circulatory apartment, it is not directly evident that their *flagella* have any agency in keeping up the inflow and outflow of currents through the afferent and efferent ostioles. Nowhere else are vibrating or non-vibrating cilia or cilia-like bodies to be met with than in the monad chambers. And since the efferent ostioles are irregularly interspersed among the much more numerous afferent ostioles, we cannot conceive how the flagella in any way could influence currents to move in a particular direction, from the smaller apertures toward the larger ones. They no doubt keep up a direct flow

of matter into the sunken chambers, but the current comes from the inner depths of the circulatory apartment, and far away from the ostioles. In this way only a turbulence of floating matter is sustained, but the general, great current is due to a far different cause. We conceive that the contraction and expansion of the body-mass in general, modified by the alternate opening and closing of the afferent and efferent ostioles, is the true motive power in this phenomenon. We have observed, often, that the outer division of the investing membrane is not kept at a uniform distance from the central, monadigerous mass; at one place it will be found to be close to its inner division, so that the circulatory apartment is very shallow there, while at another point the two divisions of the membrane are widely separated, and the circulatory apartment is very deep; and between the shallow and the deep apartments a curtain is drawn, more or less completely, extending from one pillar-like bundle of spicules to another. Each of these temporarily enclosed portions of the general apartment, it is plain now (although our actual observation on this point is very defective), may contract or expand without disturbing the contents of any other. Such an apartment with its afferent ostioles closed, may be contracting and forcing a current out at its efferent ostiole, while a neighboring apartment may have its efferent ostoile closed, and expanding, draw in current through its open afferent ostioles.

We regret that we have not the means, in this locality, for completing these researches. Our specimens were gathered, and studied on the spot where they lived, in the western part of Massachusetts, several hundred miles away from our present residence. Unfortunately we put off the attempt to feed the sponge with colored matter until we had completed other methods of investigation, and then we were prevented, by circumstances, from carrying out our designs.

In regard to the afferent and efferent canals, seen by Carter (Ann. Mag. Nat. Hist., 1857, *ut sup.*) in the monadigerous mass ("*parenchyma*" Carter), we have not met with any trace of them in the species described in this article. It is possible that they may exist in the oldest and largest individuals, but as we worked, only, on very small and transparent specimens, our direct observations, in this respect, strictly apply to the latter. It is more likely that ours is a different genus from the *Spongilla* of Carter, in favor of which we cite the curious fact that each aperture, in the inner division (not mentioned by Carter) of the investing membrane, exactly overlies and is inseparable from the entrance to a monad-chamber ("*ampullaceous sac;*" *partim*, Carter); so that whatever enters these chambers must go out by the same way that it came in; not out into a system of

branching canals, burrowed in the monadigerous mass, but into the great circulatory apartment.

Spongilla arachnoidea Jas-Cl.

DESCRIPTION OF FIGURES OF PLATE II.

The following letters apply to identical parts in all of the figures. *a*, Investing membrane; outer division.—a^1, Sectional profile of the cytoblastema of *a*.—*b*, Cells in the thickness of *a*.—b^1, Cells (like those at *b*) about the spicules (*e*).—b^2, Cells of the investing membrane, with their nucleus; a surface view.—b^3, Temporary junction (by contact only) of the outer (*a*) and inner (*c*) divisions of the investing membrane.—*c*, Investing membrane; epithelioid inner division, in sectional profile.—c^1, Interspaces between monad-chambers.—*d*, Junction of the divisions of the investing membrane along the spicules.—*e*, Larger spicules.—e^1, Smaller spicules.—*f*, Circulatory apartment.—*g*, Monadigerous mass.—*h*, Monad-chambers and monad groups.—*i*, Aperture of *h*.—*j*, Monads, or the body proper in figs. 3 and 3*a*.—*k*, Cylindrical collar of *j*.—*l*, *Flagellum*.—*n*, Nucleus.—*os*, Minor ostioles.—*v*. Contractile vesicles.—

Fig. 1. Magnified 320 diameters. Part of a very young *Spongilla*, of an oblate spheroidal form, and about $\frac{1}{25}$ of an inch in diameter. On the right is presented a face view of the investing membrane and the underlying monadigerous mass, On the left the focus is so adapted as to be fixed on a face-view of the monad-mass, and at the same time on a sectional profile of the investing membrane at a^1, b^3, *c*, and *d*.

Fig. 2. Magnified 780 diameters. Interior of a monad-chamber, seen through the aperture; the monads appear in end view, and crowded together side by side like a pavement work.

Fig. 3. Magnified 1,600 diameters. A single monad, as seen in profile in the monad-chamber. Only two contractile vesicles were present in this specimen. The cylindrical collar (*k*) is extended to its utmost.

Fig. 3*a*. Magnified 1,600 diameters. Foreshortened, front view of a monad; the body (*j*) in the distance; the hollow cylinder (*k*) projecting toward the observer like a dark hoop, and the *flagellum* (*l*) in the center appearing as a black spot.

Fig. 4. Magnified 780 diameters. Sectional view of a monad-chamber, bringing the aperture (*i*) into profile, as well as the monads which lie at the same level; thus showing their convergence about the central open space.

ART. LV.—*Description of a Printing Chronograph;* by G. W. HOUGH, Director of the Dudley Observatory.

ABOUT the year 1848, the idea of recording astronomical observations, by the use of galvanic electricity, was put in successful operation by different individuals. Since that time chronographs of various forms have been constructed for recording in a legible manner, on a moving sheet of paper, the time of any phenomenon observed. The great superiority, in point of accuracy and saving of labor, over the old eye and ear method, formerly used, led to the almost general adoption of the new plan.

During the past ten years the idea of constructing a chronograph, which should print with type the time of the observation, has been entertained by a number of persons. About five years since Prof. Hilgard of the Coast Survey, read a description

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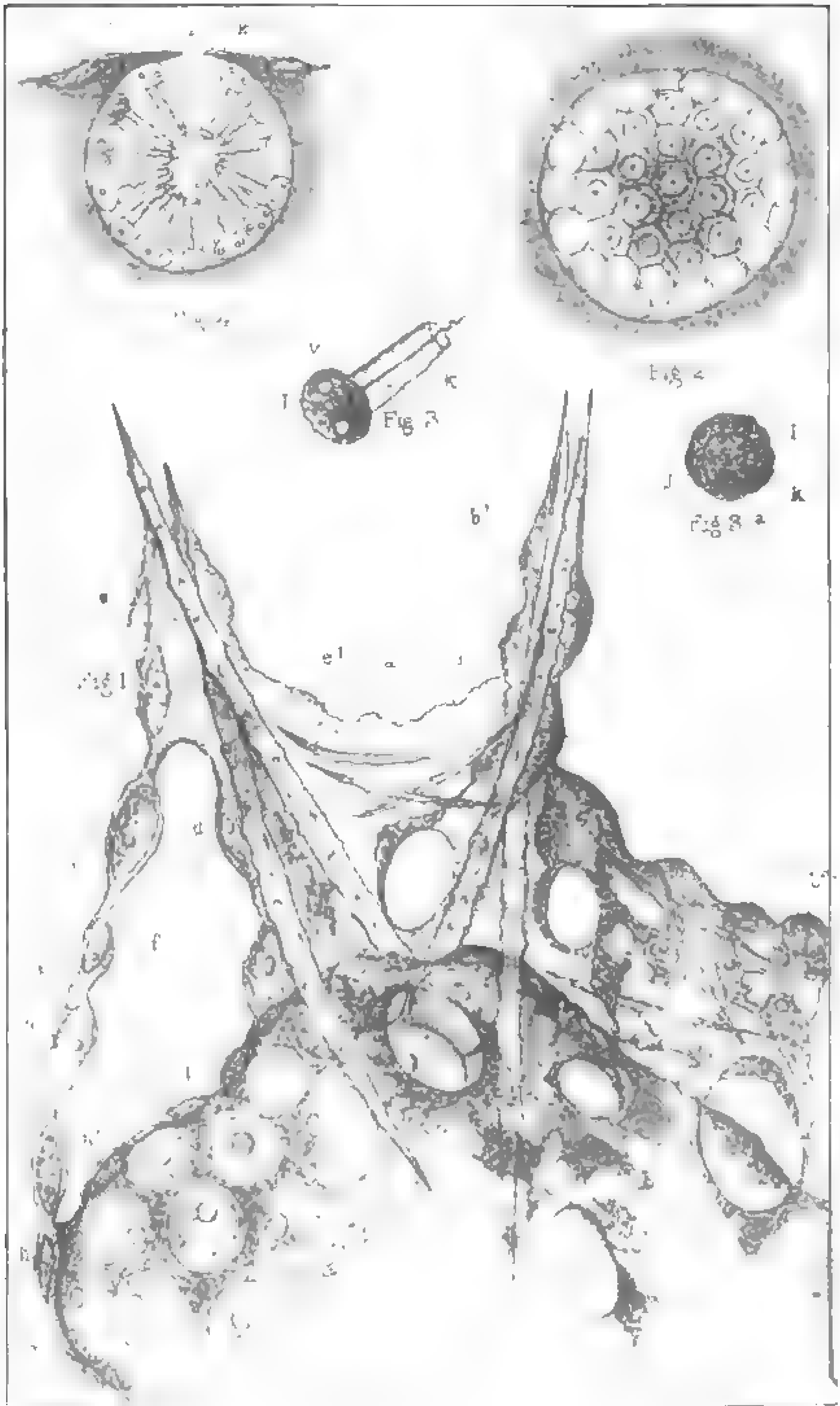

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SPONGILLA ARACHNOIDEA J-C

of an apparatus designed for this purpose, and about the same time Prof. C. A. Young, of Dartmouth College, published a proposed plan for one,* But, so far as we are informed, the mechanical construction of such an apparatus has not heretofore been attempted by any one.

The construction of a machine which shall carry a type wheel, capable of giving impressions, with uniform velocity for a number of hours together, without sensible variation in its motion, is a problem which is not easy of solution.

Some five or six years ago, in a paper read before the Albany Institute, I gave an account of the method I proposed to adopt, and in the construction of the machine, now to be described, the plan then proposed has been generally followed. My plan, which is radically different from any other proposed, is based on the principle of using separate systems of mechanism for the fast-moving type wheel, and those recording the integer minutes and seconds, regulating each with electro-magnets controlled by the standard clock.

For a clear understanding of the mechanism, elaborate drawings would be necessary. We shall, therefore, merely give a general account of its construction and peculiarities:

1st. A system of clock-work carrying a type wheel, with fifty numbers on its rim, revolving once every second; one, two, or parts of two numbers being always printed, so that hundredths of seconds may be indicated. This train is primarily regulated to move uniformly by the Frauenhofer friction balls, and secondarily by an electro-magnet acting on the fast-moving type wheel, and controlled by the standard clock. This train is entirely independent, and can be stopped at pleasure, without intefering with the other type wheels.

2nd. A system of clock-work, consisting of two or more shafts, carrying the type wheels indicating the minutes and seconds. The motion of this train is also governed by an electro-magnet, controlled by the standard clock, operating an escapement, in a manner analogous to the action of an ordinary clock; every motion of the escapement advancing the type one number.

There are three type wheels, indicating minutes, seconds and hundredths of seconds. The integer seconds are advanced at every oscillation of the standard pendulum; and the minute, at the end of each complete revolution of the seconds wheel.

The type wheels are constructed of brass disks, around the circumference of which is soldered a strip of electrotype copper, holding sixty numbers.

Presuming now we have this system of type wheels in operation, it is necessary to print without disturbing their motion;

* See this Journal, No. 124, July, 1866.

especially is this true for the fast-moving type wheel. After a long series of experiments, during which the fast moving wheel was detached and stopped in various ways, we finally made the impression from the spring of the hammer only, not allowing the blow to fall directly on the type, but arresting it about half an inch before it reached the top of the type. By this device, which is regarded of the greatest importance, the motion of the type is not disturbed an appreciable amount. Any number of impressions following each other in rapid succession, does not disturb the fast-moving wheel the one hundredth of a second. By this plan, none of the type wheels are stopped or locked in the act of printing, and records of observations may follow each other as fast as the hammer can be made to deliver the blow.

If the record is made while the type wheel indicating integer seconds is in the act of escaping, two numbers, or one number and part of another, is printed, so there is never any ambiguity about the record; this condition, of course, only occurs when the fast moving wheel indicates $0^{\cdot}95^{s}$ to $0^{\cdot}00^{s}$. If two numbers are printed when, for example, the hundredths read 98, the smaller of the integer seconds is the correct one. The time required for the action of the escapement is about 0·06 sec.

The blow for printing may be struck directly, by means of a strong electro-magnet; but the cost and trouble of keeping up a large battery for this purpose led us to do all the work mechanically, only using electricity as the governing power. Accordingly, a heavy running gear was built for raising the hammer, capable in its present form of delivering 2000 blows without rewinding; and it can be readily modified to give five times that number, if desirable. This gearing is entirely detached from the hammer when elevated, but is unlocked just before the hammer reaches the type, immediately raising it again. The time consumed for this operation is about three-tenths of a second, allowing, therefore, observations to follow each other at a minimum interval of one half second. When the hammer is elevated it is locked by an electro-magnet, the operation of this magnet allowing it to fall and print. The armature time of the hammer is about 0·07 sec., being but little in excess of our ordinary chronographic recording pen; and since the hammer is acted on by gravity alone, the armature time will be sensibly uniform.

The types are inked by means of small rollers, covered with cloth, resting against their rim, and revolving with the wheel by friction. These rollers require inking every two or three days. If desirable, the inking rollers may be dispensed with, and impression paper used instead. After numerous experiments made with both methods, we have preferred the ink.

The paper fillet, two inches in width, is wound on a small spool, holding about 60 feet, and drawn between two rollers, the same as a Morse Register. Every time the hammer falls, the fillet is advanced about one-quarter of an inch, by the action of an escapement driven by a weight. One spool of paper will hold about 1200 observations, including the spacing for different objects. This same escapement is also operated by an electro-magnet, under the control of the observer, who, by pressing a key, is able to make spaces of any width between the prints.

The train carrying the minutes and integer seconds will run eight hours; the gear for elevating the hammer will deliver 2000 blows; and the train for moving the paper fillet will go 1200 times without winding. The fast moving train runs one hour and thirty-six minutes; but since this train can be stopped at pleasure, without changing the zero of the type, its comparatively brief running is not a serious inconvenience.

To recapitulate, we claim the following:

1st, Separate movements for the integer seconds and the hundredths of seconds; 2nd, The method of regulating the hundredths of seconds wheel by an electro-magnet in connection with the standard clock; 3rd, The method of printing double or single numbers without stopping the type wheels; 4th, The method of striking the blow indirectly, using the spring of the hammer; 5th, The method of elevating and locking the hammer. The minor details for paying off the paper fillet, etc., may be accomplished in various ways.

The battery power required is about the same as for an ordinary chronograph. Three Grove elements, or six Hill's elements, work the two electro-magnets well. A separate battery of about the same size is used for the hammer and fillet magnets.

In point of accuracy, this machine leaves nothing to be desired, and is much beyond what we thought possible. From a vast number of experiments, made by recording automatically the beats of the standard clock, both at the middle and end of the oscillation, the mean error for a single print is found to be about 0·013 sec., equal in this respect to the recording chronograph. The maximum difference in the records of the beats seldom exceeds 0·03 sec.; and we believe this is as much due to the irregularity in the clock connection as in the running of the machine, since the same thing is found in ordinary chronograph records, where the measures are made from second to second.

During the building of the machine, which was accomplished by my assistant, Mr. Foreman, and myself, the past winter, as we could find the time, a great many experiments were tried

in the method of regulation, printing, etc. The fast moving train was used to propel the integer seconds and minute type wheels, dispensing with the auxiliary movement; but the disturbance of its motion was considerable, especially at the end of every minute, when it had double duty to perform.

The saving of time and labor by the use of a printing chronograph is very considerable. At the lowest estimate, it does work equivalent to the labor of one person where three are employed at the same time. In our zone work in former years, when the zone extended two hours in right ascension, it usually required the labor of two persons a whole day to convert the chronographic records into numbers and copy them on the blank forms. With the observations printed, this labor is wholly dispensed with; since the "mean" is at once deduced from the printed records.

The machine is readily adjusted to indicate the same numbers as the clock's face, the type being so set as to print zero hundredths when the pendulum is at its lowest point, where the magnetic circuit is completed. In the construction of the apparatus, provision was made for attaching engraved rings to the type wheel shaft, showing at a glance the time. But these are not found essential, as they would but little facilitate the setting of the type, which is accomplished as follows: The minute type wheel, which is free to move in either direction, is revolved to correspond to the correct minute; an impression may then be taken, and the machine started, when the clock indicates the same; the seconds being readily counted from the beats of the magnet regulating the fast moving train. The whole time for this adjustment need never exceed two minutes.

In the observation of zone stars, the type may be set to give the integer-seconds of mean right ascension, so that the final reduction will always be a small quantity.

The constant use of this mechanism on every day and observing night, for more than four months, during which time more than ten-thousand records have been made, enables us to speak with confidence of its success, both as regards correctness in printing and in saving of labor.

Other things being equal, it is found, that for three observers twice as many observations can be reduced in the same time, as when a recording chronograph is employed.

ART. LVI.—*Longitude Determination across the Continent;* by GEORGE W. DEAN. (Read before the American Association at Indianapolis.)

WITH the permission of Professor Peirce, Superintendent of the United States Coast Survey, I offer to the Association a brief statement, in regard to the method used, and the results obtained, by the Coast Survey, in determining the longitude of San Francisco and several intermediate points, by telegraphic exchange of clock signals, with Harvard College Observatory, Cambridge, Massachusetts.

In November, 1862, I was requested by the late Prof. Bache to obtain such information as might be practicable in regard to the construction of the telegraph lines across the Continent with the view of determining, by the telegraphic method, the difference of longitude between the Atlantic and Pacific coasts. He at the same time requested me to make a series of experiments with "relay magnets," generally known as "*telegraph repeaters*," for the purpose of measuring approximately the time required for transmitting a signal through one or more of those instruments. The results of those preliminary experiments were inserted by the Professor in the Appendix to his annual report for 1863, and the final results in his report for the year 1864.

I was greatly indebted to the present distinguished Secretary of the Smithsonian Institution, Professor Henry, for the success attending the experiments with "relay magnets" in 1863–64; and it is gratifying that the results then obtained have, in some degree, aided in modifying and improving the construction of the telegraph instruments now in general use in the United States. In October, 1868, I was directed by the Superintendent, Professor Peirce, to make the requisite arrangements for determining, by telegraphic exchange of clock signals, the difference of longitude between Harvard College Observatory and one of the Coast Survey stations on the Pacific coast, and to prepare a programme for conducting the operations.

The general outline of the plan was to establish an astronomical station at Omaha, Nebraska, which is, by the telegraph route, about 1550 miles from Cambridge. Also a station at Salt Lake City, Utah, which is located about 1050 miles west of Omaha, and 950 miles east of San Francisco. Professor Winlock, Director of Harvard College Observatory, coöperated with the Coast Survey, by placing his astronomical instruments at the service of the Superintendent and directing the telegraphic longitude operations at Cambridge.

The observations for determining the clock and instrumental corrections at Cambridge, were made chiefly by Assistant A. T. Mosman and Sub-Assistant F. Blake, Jr.

At Omaha, the clock and instrumental corrections were determined by Assistant Edward Goodfellow and Mr. E. P. Austin, who used a forty-six-inch transit with an aperture of two and three-fourths inches. All the observations were recorded by an astronomical clock in connection with a chronograph register. At Salt Lake City, the clock and instrumental corrections were determined by myself, assisted by Mr. F. H. Agnew, Sub-Assistant in the Coast Survey.

The instruments used were similar to those provided for the stations at Omaha and San Francisco.

Assistant George Davidson had charge of the longitude operations at San Francisco, and coöperated with Professor Winlock and myself in making the telegraphic longitude determinations across the Continent.

Cold dry weather being most favorable for exchanging telegraph signals between distant stations, arrangements were made for these experiments during the winter of 1868–69.

Whenever the weather permitted, the clock and instrumental corrections at each station were carefully determined, immediately before and after the exchange of clock signals between the several stations.

For this purpose a series of eight or ten standard zenith and two or three circumpolar stars were observed, one-half with the lamp-end of the axis *east*, and an equal number with the lamp *west*. In such a series, the probable error of the result for clock correction in no case exceeded 0·05 seconds. Mayer's formulæ, by application of the method of least squares, have been used in these reductions, which have been made in the most satisfactory manner by Captain Isaac Bradford of Cambridge.

The formulæ and a single example, for the purpose of illustrating the general arrangement of the reductions, are given with the abstract of longitude results.

In closing this paper, I will state, that on the nights of February 28th and March 7th, 1869, the Western Union Telegraph Company, with their usual liberality for the advancement of science, placed two of their telegraph lines, between Cambridge and San Francisco, at the service of the Coast Survey, for the purpose of measuring the "transmission time" of signals sent from Cambridge to San Francisco and returned, and "*vice versa.*"

The entire length of the several circuits, which were composed chiefly of No. 9 iron wire, was about 7200 miles, and the number of "*telegraph repeaters*" used was thirteen.

The results were very satisfactory, and accorded closely with the "double transmission time" deduced from the longitude determinations between Cambridge and San Francisco, and also with the results of the experiments made for "transmission time" with a single wire between those points, by Professor Winlock and Assistant Davidson.

Formulæ used in the Reductions.

Star. Lamp Tallies	
α.	
δ.	
M.	Mean of Tallies.
F.	Mean of Thread Intervals.
log F.	
log sec δ.	
log ϱ.	ϱ is the correction for rate, and its log. is 0·000005 for a gain of 1 second daily: 0·00119 for a mean time clock.
log σ.	σ is the sine correction: log σ being additive to log F; when F sec δ is less than 2^m, it may be neglected.
log R.	
R.	$R = F \sec \delta \sigma \varrho$; and is to be added to M to obtain the Time of Transit over the mean of all the threads.
b_0.	b_0 = the level correction in time, corrected for inequality of pivots: it is positive for west end high.
A.	$A = \dfrac{\sin(\varphi - \delta)}{\cos \delta}$
B.	$B = \dfrac{\cos(\varphi - \delta)}{\cos \delta}$ — 180° − δ being used instead of δ when the star is below the pole.
C.	$C = \sec \delta$
$\varkappa$.	$\varkappa$ = the diurnal aberration = sec 0·021 cos φ sec δ. It is (−) in upper and (+) in lower culminations.
Bb_0.	
T.	$T = M + R.$
t.	$t = T + Bb_0 + \varkappa.$
ω.	$\omega = \alpha - t = \Delta t + Aa \pm Cc.$
Cc.	
ω_0.	$\omega_0 = \omega \pm Cc$, upper sign for lamp west.

The collimation constant (c) is determined from reversals on circumpolar stars, and is to be obtained from the equation

$$t_e - t_w = \omega_w - \omega_e = 2Cc.$$

A is positive except for stars between the zenith and north pole.
B " " " at lower culmination.
C " " " " "

The local time and azimuth are obtained thus: assume an approximate value of the clock correction $=\theta$ for an arbitrary time T_0, and call $w - \theta = w'$; if the collimation is known and the corresponding correction applied, we have only to reduce the value of ω_0 for the several stars to the time T_0 by applying the correction for daily rate. Thus:—

$$(\omega_0) = \omega_0 + \frac{t - T_0}{24 \text{ hr.}} \times \text{daily rate},$$

and we have, putting $\Delta\theta = \Delta t - \theta$,

$$\Sigma\Delta\theta + \Sigma A a = \Sigma\omega'_0$$
$$\Sigma A\Delta\theta + \Sigma A^2 a = \Sigma A\omega'_0.$$

Whence we determine a, $\Delta\theta$, and thence Δt for the time T_0.

Reductions of the Observations for Clock and Instrumental Corrections.—February 17, 1869.

$c = +\cdot012$; hourly rate $= +\cdot005$.

Star.	ω Draconis. L. C.		ψ′ Draconis (pr), L. C.		α Orionis.	ζ Geminor.	ε Can. Maj.	δ Can. Maj.	δ Geminor.	α Can. Min.	β Geminor.	φ Geminor.
Lamp	W.	E.	E.	W.	W.	W.	W.	W.	W.	E.	E.	E.
Tallies.	F. C.	E. F.	B. C.	C. B.	C. D. E.	C. D. E.	C. D. E.	C. D. E.	D.	E. D. C.	E. D. C.	E. D. C.
	hs. min.	s.	hs. min.	s.	hs. min. sec.	hs. min. sec.	hs. min. sec.	hs. min. sec.	hs. min. sec.	hs. min. sec.	hs. min. sec.	hs. min. sec.
α	5 37	41·56	5 44	14·35	5 48 5·20	6 30 9·21	6 53 29·63	7 3 4·87	7 12 18·60	7 32 27·46	7 37 18·63	7 45 29·50
δ	+68° 48′	52·0″	+72° 12′	32·9″	+7° 22′ 37·5″	+16° 30′ 22·4″	−28° 48′ 2·2″	−26° 11′ 29·3″	+22° 14′ 8·4″	+5° 33′ 19·2″	+28° 20′ 18·6″	+27° 6′ 2·0″
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
M	5 36 24·346	5 38 34·368	5 42 49·900	5 45 19·295	5 47 52·714	6 29 56·682	6 53 17·152	7 2 52·422	7 12 6·104	7 32 14·944	7 37 6·096	7 45 16·975
F	+23·499	−23·499	+22·083	−23·519	+0·024	+0·024	+0·024	+0·024	0·000	−0·024	−0·024	−0·024
log F	1·37105	1·37105$_n$	1·344058	1·37142$_n$	8·38021	8·38021	8·38021	8·38021	−∞	8·38021	8·38021	8·38021
sec δ	0·442024	0.442024	0·514927	0·514927	0·00361	0·01829	0·05735	0·04705	0·03351	0·00205	0·05544	0·05051
log o			·02	·02								
log σ / log R	1·813074	1·813074$_n$	1·858987	1·886349$_n$	8·38382	8·39849	8·43756	8·42726	−∞	8·38226$_n$	8·43565$_n$	8·43072$_n$
R	+15·024	−15·024	+112·275	−116·975	+·024	+·025	+·027	+·027		−·024	−·027	−·027
b_0	+0·94	+·066	−·066	+·054	+·054	+·061	+·004	+·010	+·024	+·080	+·076	+·074
A	+2.	580	+2.	976	+·578	+·455	+1·080	+1·037	+0·372	+0·602	+0·276	+0·296
B	−1.	000	−1.	362	+·826	+·938	+0·368	+0·407	+1·014	+0·804	+1·102	+1·084
C	−2.	767	−3.	273	+1·008	+1·043	+1·141	+1·114	+1·080	+1·005	+1·136	+1·123
κ	+·043	+·043	+·051	+·051	−·016	−·016	−·018	−·017	−·017	−·016	−·018	−·017
Bb_0	−·094	−·066	−·090	−·074	+·045	+·057	+·002	+·004	+·024	+·064	+·084	+·080
T	5 37 29·370	5 37 29·344	5 44 2·175	5 44 2·320	5 47 52·738	6 29 56·707	6 53 17·179	7 2 52·449	7 12 6·104	7 32 14·920	7 37 6·069	7 45 16·948
t	5 37 29·319	5 37 29·321	5 44 2·136	5 44 2·297	5 47 52·767	6 29 56·748	6 53 17·163	7 2 52·436	7 12 6·111	7 32 14·968	7 37 6·135	7 45 17·011
ω	+12·241	+12·239	+12·214	+12·053	+12·433	+12·462	+12·467	+12·434	+12·489	+12·492	+12·495	+12·489
Cc					−·012	−0·13	−·014	−·013	−·013	+·012	+·014	+·013
ω_0	+12.	240	+12.	134	+12·421	+12·449	+12·453	+12·421	+12·476	+12·504	+12·509	+12·502
(ω_0)	+12.	246	+12.	139	+12·426	+12·450	+12·452	+12·420	+12·474	+12·500	+12·505	+12·497

February 17, 1869.—*Collimation.*

Star.	Time.	Cc.	C.	c.
	h. m.			
ω Draconis L. C.	5 37	+ ·001	−2·767	−·0004
ψ′ Draconis L. C.	5 44	−·0805	−3·273	+ ·0246

$T_0 = 6h.\ 46m.\quad \theta = +12{\cdot}550.$

Clock and Azimuth Corrections.—Observer A. T. M.

Star.	Lamp.	(ω_0)	A	ω'_0	A^2	$A\omega'_0$	Aa	Δt
ω Draconis L. C.	W. E.	+12·246	+2·580	−·304	6·656	−0·784	−·312	12·558
ψ Draconis (pr) L. C.	E. W.	+12·139	+2·976	−·411	8·857	−1·223	−·360	12·499
α Orionis,	W.	+12·426	+0·578	−·124	·335	−0·072	−·070	12·496
ζ Geminor,	W.	+12·450	+0·455	−·100	·207	−0·046	−·055	12·505
ε Can. Maj.	W.	+12·452	+1·080	−·098	1·167	−0·106	−·131	12·583
δ Can. Maj.	W.	+12·420	+1·037	−·130	1·076	−0·185	−·125	12·545
δ Geminor,	W.	+12·474	+0·372	−·076	·139	−0·028	−·045	12·518
α Can. Min.	E.	+12·500	+0·602	−·050	·363	−0·030	−·073	12·573
β Geminor,	E.	+12·505	+0·276	−·045	·076	−0·012	−·033	12·538
φ Geminor,	E.	+12·497	+0·296	−·053	·088	−0·016	−·036	12·533
			+10·252	−1·391	18·964	−2·452	+	12·535

$$10\ \Delta\theta + 10{\cdot}252\ a = -1{\cdot}391 \qquad \Delta\theta - {\cdot}1240 = -{\cdot}1391$$
$$+10{\cdot}252\ \Delta\theta + 18{\cdot}964\ a = -2{\cdot}452 \qquad \Delta\theta = -{\cdot}015$$

$$\Delta\theta + 1{\cdot}0252\ a = -0{\cdot}1391$$
$$+10{\cdot}251\ \Delta\theta + 10{\cdot}510\ a = -1{\cdot}426 \qquad \Delta t = +12{\cdot}535 \pm {\cdot}007$$
$$+ 8{\cdot}454\ a = -1{\cdot}026$$
$$a = -0{\cdot}121$$

Longitude between Cambridge and Omaha.

[Not corrected for personal equation.]

Date 1869.	$\lambda + \chi_2$ h. m. s.	Probable error.	No. of Series of Signals.	$\lambda - \chi_1$ h. m. s.	Probable error.	No. of Series of Signals.
Feb. 17,	1 39 15·305	±·018	2	1 39 14·990	±·015	3
" 18,	15·293	±·033	2	14·960	±·030	2
" 24,	15 278	±·028	3	14·999	±·032	2
" 25,	15·351	±·015	2	15·009	±·015	2
" 27,	15·351	±·031	1	15·007	±·015	4
" 28,	15·384	±·034	1	14·982	±·033	1
Mean						

Date 1869.	2λ h. m. s.	Probable error.	λ h. m. s.	Probable error.	$\chi_1 + \chi_2$ Double transmission time.
Feb. 17	3 18 30·295	±·023	1 39 15·147	±·012	0s·315
" 18	30·253	±·045	15·127	±·022	0·333
" 24	30·277	±·043	15·138	±·021	0·279
" 25	30·360	±·021	15·180	±·011	0·342
" 27	30·358	±·034	15·179	±·017	0·344
" 28	30·366	±·047	15·183	±·024	0·402
Mean			1 39 15·159	±·008	0·366

NOTE.—Telegraph repeaters were used at Buffalo and Chicago.

Length of telegraph wires in circuit between Cambridge and Buffalo, 504 miles; Buffalo and Chicago, 540 miles; Chicago and Omaha, 498 miles.

Longitude between Cambridge and Salt Lake City.—Not corrected for personal equation.

Date 1869.	$\lambda - \chi_2$ h. m. s.	Probable error.	No. of Series of Signals.	$\lambda - \chi_1$ h. m. s.	Probable error.	No. of Series of Signals.	2λ h. m. s.	Probable error.	λ h. m. s.	Probable error.	$\chi_1 + \chi_2$ Double transmission time.
Feb. 17	2 43 4·497	±·042	1	2 43 3·966	±·030	2	5 26 8·463	±·052	2 43 4·232	±·026	0s·531
" 18	4·609	±·025	2	3·986	±·025	2	8·595	±·035	4·297	±·018	0·623
" 19	4·576	±·022	--	3·985	±·012	3	8·561	±·025	4·280	±·013	----
" 24	4·487	±·035	1	3·982	±·033	2	8·469	±·048	4·235	±·024	0·505
" 25	4·596	±·029	2	3·989	±·028	2	8·585	±·040	4·293	±·020	0·607
" 27	4·563	±·030	2	3·908	±·035	3	8·471	±·046	4·236	±·023	0·655
" 28	4·501	±·041	1	3·827	±·029	2	8·328	±·050	4·164	±·025	0·674
Mar. 3	4·588	±·054	1	4·048	±·040	2	8·636	±·067	4·318	±·034	0·540
Mean									2 43 4·257	±·008	0·591

NOTE.—Telegraph repeaters were used at Buffalo, Chicago, Omaha and Cheyenne.
The length of telegraph wire in the circuit between Cambridge and Salt Lake City was 2583 miles.

Longitude between Cambridge and San Francisco.—Not corrected for personal equation.

Date 1869.	$\lambda + \chi_2$ h. m. s.	Probable error.	No. of Series of Signals.	$\lambda - \chi_1$ h. m. s.	Probable error.	No. of Series of Signals.	2λ h. m. s.	Probable error.	λ h. m. s.	Probable error.	$\chi_1 + \chi_2$ Double transmission time.
Feb. 17	3 25 7·706	±·020	2	3 25 6·917	±·020	2	6 50 14·623	±·028	3 25 7·311	±·014	0s·789
" 18	7·715	±·018	4	6·834	±·031	1	14·549	±·036	7·275	±·018	0·881
" 24	7·629	±·027	2	6·843	±·038	1	14·472	±·047	7·236	±·023	0·786
" 25	7·718	±·024	1	6·865	±·024	1	14·583	±·084	7·292	±·017	0·853
" 27	7·728	±·035	1	6·907	±·023	2	14·635	±·042	7·317	±·021	0·821
" 28	7·615	±·027	2	6·693	±·034	1	14·308	±·044	7·154	±·022	0·922
Mar. 3	7·635	±·042	1	6·859	±·047	1	14·494	±·064	7·247	±·032	0·776
" 5	7·633	±·029	1	6·823	±·029	1	14·456	±·042	7·228	±·021	0·810
" 7	7·637	±·022	2	6·923	±·028	1	14·560	±·036	7·280	±·018	0·714
Mean									3 25 7·260	±·007	0·817

NOTE.—Telegraph repeaters were used at Buffalo, Chicago, Omaha, Cheyenne, Salt Lake City, and Virginia City.
The length of telegraph wire in the circuit between Cambridge and San Francisco was about 3580 miles.

Longitude Determinations across the Continent, January and February, 1869. (Final results.)

Personal Equations.

Dean — Mosman $= +0^s{\cdot}11$ }
Goodfellow — Dean $= +0{\cdot}02$ } From Gould's Report of May, 1867, p. 75.

Dean — Davidson $= +0{\cdot}180$ { From observations made at San Francisco, April, 1869.

Station.	Observer.	Dean's Standard.	
Cambridge,	Mosman,	$+0^s{\cdot}110$	To be applied to the clock corrections of the respective stations to reduce them to Dean's standard.
Omaha,	Goodfellow,	$-0{\cdot}020$	
Salt Lake,	Dean,	$0{\cdot}000$	
San Francisco,	Davidson,	$+0{\cdot}180$	

To correct the differences of longitude for personal equation, we have:—

Cambridge Time	—	Omaha Time		$=+0^s{\cdot}130$
" "	—	Salt Lake Time		$=+0{\cdot}110$
Omaha "	—	" "		$=-0{\cdot}020$
Cambridge "	—	San Francisco Time		$=-0{\cdot}070$
Omaha "	—	" "		$=-0{\cdot}200$
Salt Lake "	—	" "		$=-0{\cdot}180$

STATIONS.	Difference of Long. (λ).	Personal equation.	Corrected difference of Longitude.	Double transmission time.
	h. m. s.	*s.*	*h. m. s. s.*	*s. s.*
Cambridge to Omaha	1 39 15·159	+·130	1 39 15·289 ± ·008	·336 ± ·015
Cambridge to Salt Lake	2 43 4·257	+·110	2 43 4·367 ± ·008	·591 ± ·019
Omaha to Salt Lake	1 3 49·081	—·020	1 3 49·061 ± ·008	·260 ± ·016
Cambr'ge to S. Francisco	3 25 7·260	—·070	3 25 7·190 ± ·007	·817 ± ·014
Omaha to San Francisco	1 45 52·094	—·200	1 45 51·894 ± ·010	·483 ± ·023
Salt Lake to S. Francisco	0 42 3·024	—·180	0 42 2·844 ± ·008	·242 ± ·016

STATIONS.	Difference of Longitude.	$\chi_1 + \chi_2$
	h. m. s. s.	*s. s.*
Cambridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
Omaha to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
Cambridge to Salt Lake (sum),	2 43 4·350 ± ·011	·596 ± ·022
" " (direct),	2 43 4·367 ± ·008	·591 ± ·019
Difference,	·017 ± ·014	·005 ± ·029
Cambridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
Omaha to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
Salt Lake to San Francisco,	0 42 2·844 ± ·008	·242 ± ·016
Cambridge to San Francisco (sum),	3 25 7·194 ± ·014	·838 ± ·027
" " (direct),	3 25 7·190 ± ·007	·817 ± ·014
Difference,	·004 ± ·016	·021 ± ·030
Omaha to Salt Lake,	1 3 49·061 ± ·008	·260 ± ·016
Salt Lake to San Francisco,	0 42 2·844 ± ·008	·242 ± ·016
Omaha to San Francisco (sum),	1 45 51·905 ± ·011	·502 ± ·023
" " (direct),	1 45 51·894 ± ·010	·483 ± ·023
Difference,	·011 ± ·015	·019 ± ·032
Cambridge to Omaha,	1 39 15·289 ± ·008	·336 ± ·015
Omaha to San Francisco,	1 45 51·894 ± ·010	·483 ± ·023
Cambridge to San Francisco (sum),	3 25 7·183 ± ·013	·819 ± ·027
" " (direct),	3 25 7·190 ± ·007	·817 ± ·014
Difference,	·007 ± ·015	·002 ± ·030

STATIONS.	Difference of Longitude.	$\chi_1 + \lambda_1$
	h. m. s. s.	s. s.
Cambridge to Salt Lake,	2 43 4·367 ± ·008	·591 ± ·019
Salt Lake to San Francisco,	0 42 2.844 ± ·008	·242 ± ·016
Cambridge to San Francisco (sum),	3 25 7·211 ± ·011	·833 ± ·025
" " (direct,	3 25 7·190 ± ·007	·817 ± ·014
Difference,	·021 ± ·013	·016 ± ·029
Cambridge to San Francisco,	3 25 7.190 ± ·007	·817 ± ·014
(C. to O.)+(O. to S. L.)+(S. L. to S. F.)	7·194 ± ·014	·838 ± ·027
(C. to O.)+(O. to S. F.)	7·183 ± ·013	·819 ± ·027
(C. to S. L.)+(S. L. to S. F.)	7 211 ± ·011	·833 ± ·025
Cambridge to San Francisco (Mean of all),	3 25 7·194 ± ·006	·827 ± ·012

ART. LVII.—*Notice of the Invertebrata dredged in Lake Superior in* 1871, *by the U. S. Lake Survey, under the direction of Gen. C. B. Comstock, S. I. Smith, naturalist;* by S. I. SMITH and A. E. VERRILL.

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DURING the explorations in Lake Superior, mentioned in the last number of this Journal (page 373) the following species were obtained, together with a number of minute forms, which have not been determined.

A full account of the expedition, with descriptions of the species collected, will be published in the official report of the expedition.

RADIATA.

Hydra carnea Agassiz. A beautiful *Hydra*, agreeing with Ayer's description of this species, was very abundant at the eastern end of St. Ignace, upon rocks along the shore and near the surface, frequently completely covering quite large surfaces where they were protected from the direct sunlight, and was also brought up in many of the dredgings from 8 to 148 fathoms. In 32 fathoms, Neepigon Bay, and in 59 fathoms, off Simmon's Harbor, it was brought up in abundance from a soft clayey bottom. In the deep dredgings, it frequently came up near the bottom of the clay in the dredge, and was evidently not caught while the dredge was near the surface.

MOLLUSCA.

Limnæa. A species allied to *L. disidiosa* Say, was abundant among *Cladophora* in 8 to 13 fathoms on the south side of St. Ignace Island.

Physa heterostropha Say. In the cove at the eastern end of St. Ignace, in 4 to 6 fathoms, and young specimens, in 8 to 13 fathoms, at the locality with the *Limnæa* just mentioned.

Physa vinosa Gould. A very young specimen, apparently of this species, in 6 to 8 fathoms among the Slate Islands.

Planorbis parvus Say. Common in 8 to 13 fathoms on the south side of St. Ignace.

Valvatu sincera (Say sp.). Abundant with the last species, in 8 to 13 fathoms, and also, in 4 to 6 fathoms, in the cove at the eastern end of the same island.

Sphærium sp. nov.? Among the Slate Islands, in 6 to 8 fathoms. A single young specimen of another species of *Sphærium* was found, in 8 to 13 fathoms, on the south side of St. Ignace.

Pisidium Virginicum Bourguignat. On the south side of St. Ignace, 8 to 13 fathoms.

Pisidium abditum Haldeman. With the last species, in 8 to 13 fathoms, and also, in 4 to 6 fathoms, in the cove at the eastern end of the same island.

Pisidium compressum Prime. In the cove at the eastern end of St. Ignace, 4 to 6 fathoms.

Pisidium sp. nov. A small, semi-translucent species, the same as found by Dr. Stimpson in Lake Michigan, was brought up at nearly every dredging. It was common in the cove at the eastern end of St. Ignace, on sandy and muddy bottom, in 4 to 6 fathoms, and abundant among *Cladophora*, in 8 to 13 fathoms, on the south side of that island; among the Slate Islands, in 6 to 8 and 12 to 14 fathoms; at 13 to 15 fathoms on a sandy bottom in Simmon's Harbor; near Copper Harbor, in 17 fathoms, clear sand; in 32 fathoms, very soft clayey mud, in Neepigon Bay; off Copper Harbor, in 62 fathoms, and north of Keweenaw Point, in 82 fathoms, soft reddish clayey mud and sand; and in all the deep dredging down to 159 fathoms.

Worms.

Lumbricus lacustris Verrill, sp. nov. About 1·5 inches long, ·04 in diameter. Body round, distinctly annulated. Head short, conical, obtusely pointed. Setæ spine-like, strongly curved, acute, arranged two by two, those of each pair close together. Color reddish brown.

South side of St. Ignace, among *Cladophora*, 8 to 13 fathoms.

Sænuris abyssicola Verrill, sp. nov. Worm slender, attenuated posteriorly, about ·30 of an inch long, ·03 in diameter anteriorly. Body composed of about 28 segments, those of the posterior half elongated; those of the anterior half shorter, separated by slight constrictions. Cephalic lobe short, subconical, rounded in front. Mouth large, semi-circular. Intestine slender, moniliform, containing sand. Anus terminal, with three or four slight lobes. Setæ in four, fan-shaped fascicles on each segment, commencing at second segment behind the mouth. The two ventral fascicles are separated by a space equal to about twice the length of the setæ, of which there are five or six in each fascicle; the satæ are simple, acute, slightly curved, equal to

about one-sixth the diameter of the body. The lateral fascicles contain three to five somewhat shorter and straighter simple setæ. One specimen appeared to have four minute ocelli upon the upper side of the head.

Off Copper Harbor, 17 fathoms, sand; off Simmon's Harbor, 60 fathoms; and on the line from the Slate Islands toward Stannard Rock, fourth haul, 159 fathoms.

Sænuris limicola Verrill, sp. nov. Worm more slender than the preceding, attenuated posteriorly, composed of about 44 segments. Length about ·33 of an inch, diameter ·02. Cephalic lobe blunt, conical. Setæ in four fascicles upon each segment, six to eight in each fascicle anteriorly, four or five posteriorly. The setæ in all the fascicles are relatively long, slender, curved and acute. Two tortuous red blood vessels pass along the intestine, forming a loop at each segment. Intestine moniliform.

On the line between the Slate Islands and Stannard Rock, fourth haul, 159 fathoms.

Chirodrillus, gen. nov. Allied to *Sænuris*, but with six fan-shaped fascicles of setæ upon each segment, two of which are ventral, two lateral, and two sub-dorsal; setæ in the ventral and lateral fascicles four to nine, simple, acute, slender, curved like an italic *f*; those of the dorsal fascicles, stouter and less curved, three to six in each fascicle. Intestine wide, somewhat moniliform. Anus terminal, large.

Chirodrillus larviformis Verrill, sp. nov. Body rather short and not very slender, cylindrical, obtuse at both ends, distinctly annulated, composed of about 38 rings. Length about ·30 of an inch; diameter ·05. Cephalic lobe short, conical, obtuse, mouth large, semi-circular beneath. Ventral fascicles of setæ near together, with about five setæ, which are rather short, simple, acute, little curved; lateral fascicles with five or six setæ of similar form and size; sub-dorsal ones similar. When preserved in alcohol, the body is usually curved ventrally or in a simple coil. Color, when living, translucent whitish, intestine slightly greenish. A thickened smooth zone commences behind the 10th setigerous ring, occupying the space of about four segments.

Off Copper Harbor, 17 fathoms, sand; off Simmon's Harbor, 59 fathoms, clayey mud.

Chirodrillus abyssorum Verrill, sp. nov. Sub-cylindrical, thicker anteriorly, distinctly annulated, composed of about 42 segments. Length ·25 of an inch; diameter about ·02. Cephalic lobe short, conical, obtuse, mouth large, semi-circular. Ventral fascicles with eight or nine setæ anteriorly, five or six posteriorly. The setæ are long, slender, acute, strongly curved, those on the inferior side of the fascicles nearly twice as long as those of the upper side; setæ of the lateral fascicles five or six, slender, nearly as long as those of the ventral ones, and similar in form;

dorsal fascicles with four or five shorter, stouter, and straighter, acute setæ.

Six miles S.E. of Passage Island, 47 fathoms; on line from the Slate Islands toward Stannard Rock, fourth haul, 159 fathoms.

Tubifex profundicola Verrill, sp. nov. A rather stout species for the genus, about 1 to 1·5 inches long, ·05 in diameter anteriorly, more slender posteriorly (·02 in diameter). Cephalic lobe short, conical: one specimen apparently had two minute ocelli. Mouth large, semi-circular. Intestine moniliform, with two simple red blood-vessels running along its whole length and uniting at the constrictions. In the first five or six segments there are slender vessels of nearly uniform size, which form lateral loops in each segment. Anus terminal, wide, with about ten small lobes. Setæ in four fascicles upon each segment. Those of the lateral fascicles three anteriorly, often but two, short, slightly curved, mostly with minute forked and hooked tips; those of the ventral series in fascicles of four to six, three or four times longer than the upper ones, considerably bent, the ends minutely hooked and forked.

Neepigon Bay, 32 fathoms.

Nephelis fervida Verrill, sp. nov. Leech two or three inches long, ·20 to ·30 wide, elongated and slender in full extension, very little depressed, most so posteriorly, often round and tapering anteriorly. Mouth large, nearly circular, subterminal, the upper lip, in contraction, short and rounded; corrugated within the œsophagus with three conspicuous folds, eyes eight, blackish, conspicuous, two pairs, a little apart, on the first ring of the head; two pairs wider apart and farther back on the third ring. Color bright brick-red, when living.

In 8 to 13 fathoms, south side of St. Ignace.

A small specimen, probably the young of this species, taken in 13 to 15 fathoms, in Simmon's Harbor, was translucent, tinged with flesh color, with a dark brown intestinal line posteriorly.

Nephelis lateralis Verrill (*Hirudo lateralis* Say). A small specimen, about 1 inch in length, of an obscure liver-brown color, was taken, in 6 to 8 fathoms, among the Slate Islands, which probably belongs to this species.

Ichthyobdella punctata Verrill, sp. nov. Body, in extension, slender, in the preserved specimen, about ·5 of an inch long, ·06 in greatest diameter, rounded, thickest posteriorly, tapering anteriorly to the anterior sucker, which is broad and thin, sub-circular, about three times as wide as the neck where it is attached. Ocelli four, on the upper side of the anterior sucker, the two larger, black ones, in front, and two minute ones wider apart and farther back. Posterior sucker large, rounded or oval. Color translucent greenish, with minute black specks arranged in transverse bands.

Among the Slate Islands, 6 to 8 fathoms.

Procotyla fluviatilis Leidy. Numerous specimens, apparently of this species, were obtained in 8–13 fathoms on the south side of St. Ignace. They were, when living, dirty white, mottled with brown.

In addition to the preceding species of worms, a few were obtained which have not yet been fully determined.

CRUSTACEA.

Mysis relicta Lovén. The occurrence of this and the following species, identical with forms from Lake Michigan, and the lakes of northern Europe, is mentioned in the last number of this Journal. It was brought up with sand and mud from 12 to 14 fathoms at the eastern end of St. Ignace, from 8 to 13 fathoms, with *Cladophora*, on the south side of the same island, and from deep water in a large proportion of the hauls from 73 to 148 fathoms.

Pontoporeia affinis Lindström. This species was found at every haul from the shallowest to the deepest.

Crangonyx gracilis Smith, sp. nov. Eyes slightly elongated, black, composed of few facets. Antennulæ slender, slightly more than half as long as the body; secondary flagellum but little longer than the basal segment of the primary. Antennæ much shorter than the antennulae; the flagellum and peduncle of about equal length, the peduncle being a little longer than the peduncle of the antennulæ. Gnathipoda sub-equal in both sexes, the second pair being only slightly larger than the first; propodus in the first pair quadrate, the palmary margin transverse, nearly straight, and armed with slender spines, of which one or two at the prominent posterior angle are much larger than the others; propodus in the second pair like those of the first, but a little more elongated and the palmary margin slightly oblique. Third, fourth and fifth pairs of pereiopoda equal in length and the margins of their basa spinulose. Ultimate pleopoda reaching to the tips of the penultimate; the outer ramus nearly twice as long as the peduncle, and armed with slender spines; the inner ramus very minute, shorter than the width of the outer. Telson scarcely as long as the bases of the ultimate pleopoda, slightly broader than long, and the posterior margin with a triangular emargination, either side of which the extremity is truncate and armed with several spines.

The incubatory lamellæ of the female are very large, projecting much beyond the coxæ of the anterior legs, as in *C. recurvatus* Grube, which our species much resemble in the form of the antennulæ, antennæ, gnathepoda, etc., while it differs much in the ultimate pleopoda and in the form of the telson. Length, 5 to $7^{mm.}$

Among *Cladophora*, in 8 to 13 fathoms, on the south side of St. Ignace.

Gammarus lacustris Smith, sp. nov. Eyes slightly elongated, black. Antennulæ not quite half as long as the body, and furnished with a few short hairs; first and second segments of the peduncle equal in length, third much shorter; flagellum twice as long as the peduncle. Antennæ a little shorter than the antennulæ; ultimate and penultimate segments of the peduncle equal in length, the basal segments short; flagellum considerably shorter than the peduncle. Gnathipoda about equal in size; propodus in the first pair elongated and much narrowed toward the articulation of the propodus; palmary margin slightly concave, continuous with the posterior margin, and furnished, like it, with several stout spines and numerous long hairs, dactylus slightly curved and fully half as long as the propodus; propodus in the second pair a little broader, the lateral margins nearly parallel, the palmary margin somewhat oblique, slightly concave, and furnished with a thin raised margin, and several stout spines, the posterior margin without spines, but furnished with numerous fascicles of hairs. Pleon rounded above, the fourth and fifth segments each with three fascicles of two or three small spines. Third, fourth, and fifth pairs of pereiopoda sub-equal, their basa narrow and the margins furnished with few minute spines. Rami of the posterior pair of pleopoda very slender, the edges furnished with long hairs and a few spines, inner only a little shorter than the outer. Length, 15 to 20^{mm}.

Color in life uniform, obscure, dark brownish-green, without spots or markings of any kind.

Common in company with the last species in 8 to 13 fathoms; also at Simmon's harbor, in 13 to 15 fathoms, and among the Slate Islands, in 4 to 6 and 12 to 14 fathoms.

Asellus tenax Smith, sp. nov. Head broad, with a large rounded sinus in the margin on each side opposite the eye, back of which the margin projects in a rounded lobe, so that the head is not narrower posteriorly than the anterior margin of the first segment of the pereion. Eyes small, prominent, and separated from the margin of the head by more than their diameters. Antennulæ much shorter than the peduncles of the antennæ. Antennæ half as long as the body; the flagellum longer than the peduncle. Propodus in the first pair of gnathipoda narrow and elongated, but considerably stouter in the male than in the female; dactylus more than half as long as the propodus and its palmary edge armed with acute spines, of which the distal ones are larger. The succeeding pairs of legs all similar, the carpal and propodal segments subequal in length and armed with short spines along the posterior

edges; the dactyli short, armed with a few spines on the posterior margin, and bi-unguiculate at tip. Pleon narrowed posteriorly, and the extremity obtusely rounded. Posterior pleopoda slender, the outer ramus only half as long as the inner. Length, 8 to 13^{mm}.

Color above dark fuscous, spotted and mottled with yellowish.

Common with the last two species, among the *Cladophora*, in 8 to 13 fathoms; also in 4 to 6 fathoms at the eastern end of St. Ignace, and in 6 to 8 fathoms among the Slate Islands.

Numerous species of Entomostraca were collected at many places, but they have not yet been examined sufficiently for an enumeration of the species.

In addition to the species of the groups already mentioned, insect larvæ and pupæ were obtained at nearly every haul. Several species of *Chironomus*, or of closely allied genera, were common, a slender translucent species being found down to 147 fathoms; an Ephemerid lava occurred at 32 fathoms in Neepigon Bay, and two species of *Phryganeidæ* larvæ were common among *Cladophora* in 8 to 13 fathoms on the south side of St. Ignace.

ART. LVIII.—*On Kilauea and Mauna Loa;* by Rev. TITUS COAN. (From a letter to J. D. Dana, dated Hilo, Aug. 30.)

DURING the present month I have, in connection with my pastoral labors, visited Kilauea and the whole coast of Puna. I had not seen the volcano since July, 1869, more than a year after the great earthquake and eruption of April, 1868. At this visit, in 1869, I found the crater very quiet. The central and *convex* part had subsided some four hundred feet, forming a vast *concave*, and leaving a high, serrous, black ledge around the circumference of the crater. The south lake was not included in the central basin or depression; but it formed a much deeper pit within the southern rim of the black ledge. The whole crater of Kilauea was then quiescent, with light puffs of long, white steam rising here and there. There were no demonstrations, and so nearly cooled was the bottom of that great south lake—Halemaumau—that I went down into it some *twelve hundred feet below the upper rim of Kilauea*, and measured across the floor. I found the diameter five-sixths of a mile, the pit being more than a mile wide from the upper north to the upper south rim. There were several places, however, at that time, where the incandescent rocks were seen boiling fiercely, through fissures, in caverns fifty to one hundred feet below. Such was the state of the crater on my visit in July, 1869.

On my recent visit, two years later, I found great changes. The south lake had been filled with molten lavas, and successive

overflowings had covered deeply all the southern end of the crater, and sent off their fiery streams two miles to the north, covering the great central depression to the depth of fifty feet.

Mr. L. Kaina, an observant and intelligent Hawaiian, who keeps a respectable hotel at the volcano, told me that, from April to October, 1870 (while I was in the United States), repeated and grand overflowings occurred from Halemaumau, the fiery waves surging and dashing down the northern declivities, filling the whole crater with intense heat and stifling gases; it threw up a sheet of lurid light toward the zenith, producing the appearance of a firmament in conflagration, and reminding one of the bold figures of Peter in speaking of "the heavens being on fire . . . and the elements melting with fervent heat."

My informant told me that he, several times, witnessed what I have more than once seen, viz: the fiery lake rising slowly to the rim, boiling and spilling over, and, by hardening in successive strata, raising a circular dam or barrier around the whole circumference of the lake, some fifteen to twenty-five feet high. Within this circular dike or raised rim the molten sea boils and rages until the heat, the action, and the lateral pressure burst the conical shell, when the seething flood rushes out with awful power, and covers a vast area with its burning waves. Such a scene I witnessed shortly after I lost your pyrometer, which had been thrust into a fiery lake such as is here described. I judge that the overflowings from this south lake, during my absence, cover four square miles to a depth of fifty to three hundred feet—the deepest portion being an elevated region lying all around Halemaumau—and extending east, south, and west, to the outer walls of Kilauea, and flowing down a steep slope to the north, and sweeping over the great central concave.

I was in the crater on the 22d instant, and was at once surprised with the great changes manifest. I had no sooner descended from the northern terrace, or black rim, than I found myself on new ground. All old tracks and landmarks were obliterated. All was *recast*. About half a mile from the south lake I began to rise on an angle of some 25° until I was on a level with the rim of the cauldron. About three hundred yards from the pit the heat was so great, and the gases so pungent, that I could not proceed in a direct line to the margin. Being driven back I made a detour, and again attempted a direct approach. Failing in this, I retreated to a safer atmosphere, and then flanked the fiery pit at some distance, traveling southwestward for half a mile. Here I found the smoke and gases lighter, and again I advanced on the crater at right angles. With difficulty I succeeded in reaching the rim, and a puff of wind favoring by sweeping off the dense smoke of the pit in another direction, I caught a twenty-second glimpse of the awful abyss below. I judged the pit of Halemaumau to be seven hundred feet deep, one mile and a half long from east to west, and one mile from north to south. But it was full of dense columns of smoke and sulphurous gases which were rapidly rising

from burning depths below, and being carried by the winds over all the regions I wished to traverse. Almost immediately after the opening, which revealed to me the profound depths of the fiery abyss, the whole pit was packed and darkened with still denser clouds of smoke, which the fitful wind began to drive upon me. I made a hasty retreat to the northwest, where I reached the original black-terrace, and, mounting an inactive cone some twenty-five feet high, rested in a current of cooler and purer air, and surveyed the marvelous scene I had just left. There is a great body of molten matter in this pit, recognized by its sullen mutterings, and splashings and surgings, and by the bloody glow thrown upon the uprising columns of smoke at night. But the heat and smoke are so great, that it is unsafe to approach the rim of the crater, and usually impossible to see the bottom even could you reach the margin of the pit.

The immense quantities of lava which came from this pit were not all thrown over the upper rim. After this rim had been raised, with all the surrounding area, to a great height, the molten floods formed subterranean passages to the lower parts of Kilauea, where they burst out, and spread seas of liquid fire over the surface.

An active Crater on Mauna Loa.—While at Kilauea, the atmosphere being clear at night, I had a view of an active volcano on Mauna Loa some 13,000 feet high, and about four miles south by west of Mokuaweoweo, the summit crater. This volcano has been burning for weeks, though not often seen at Hilo on account of clouds. Its bearing is about southwest from Hilo, and, as I judge, about north from Kahuku in Kau. It is said that several Hawaiians of Kau have visited it. They say that it is a small lateral crater of Mokuaweoweo, about four miles distant. It has long been extinct, but it now boils in fiery swirls, much like Kilauea. Its action is unequal, sometimes throwing up brilliant jets, and clouds of smoke, and anon seething quietly in its deep caverns. It has not overflowed its rim, or rent its mural walls, or found any subterranean vent by which the molten lake passes off. From week to week and month to month it burns in solitude, and shines like a beacon light upon the dark mountain. Most of the time it is hidden from us by clouds; but when the old mountain—the mother of volcanoes—removes her misty veil, we can then see its distant light.

Some thirty-five or forty miles from Kilauea, and about 9,000 feet above it in altitude, how is it that we can see no sympathy that proves a subterranean connection?

We have occasional shocks of earthquake. From Kilauea I went down to the coast of Puna, and followed its shores to Hilo. The great subsidence of April, 1868, still remains. In most places the people have removed from the shore and built half a mile to two miles inland. In some places they now catch fish where once they cultivated vegetables and grazed their horses. The debris of that little cataclysm is still strewn along the shores of Puna and Kau.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the sensitiveness to light of the haloid salts of silver, and the connection between optical and chemical absorption of light.*—SCHULTZ-SELLACK has published with the above title a very interesting memoir, the principal results of which are, in the author's words, as follows:

(1.) In the case of a mixture of chlorine and hydrogen the curve of the chemical intensity of the spectrum which shows the relative chemical action which the different colors exert when completely absorbed, has a course different from that of the curve which directly expresses the observations of Bunsen and Roscoe, and probably more nearly resembles the curve of heat-intensity.

(2.) The sensitiveness to light, determined by photographic excitement, extends in the case of chloride of silver from the ultra-violet to $\frac{2}{3}$ HG; in the case of iodide of silver to $\frac{1}{8}$ GF; in the case of bromide of silver to $\frac{4}{5}$ GF, with iodo-bromide and iodo-chloride of silver to beyond E.

(3.) The dark coloration of haloid salts of silver exposed to the spectrum takes place in the case of chloride of silver within the extent of the photographic excitability; this is probably also the case with the other haloid salts.

(4.) In the case of the haloid salts of silver the absorption of light is always accompanied by chemical decomposition. These salts exert a perceptible absorption upon the spectrum only within the above mentioned limits of photographic excitability.

(5.) Only a small fraction of the absorbed light is converted into chemism. This fraction is different for different colors, but is never zero.

(6.) A thin film of iodide of silver absorbs the light which is more refrangible than G very strongly, the light between G and $\frac{1}{8}$ GF but feebly; this last is, however, photographically active. In photographing upon iodide of silver, the interposition of a thin film of the iodide acts like illumination with light approximately homogeneous from G to $\frac{1}{8}$ GF.

(7.) At a higher temperature the coloration of the haloid salts of silver becomes deep brown. The sensitiveness to light then probably extends to the red of the spectrum.

(8.) The application of the term *chemical rays* to the more strongly refrangible rays of the spectrum has no other signification than that known substances sensitive to light specially absorb precisely these rays.—*Pogg. Ann.*, cxliii, p. 161. W. G.

2. *On the proteine series.*—HLASIWETZ and HABERMANN have taken up the study of this somewhat neglected subject, and have arrived at results of much interest. The authors in the first place pass in review the results obtained many years since by the study of the products of the action of various reagents upon members of

the proteine group. These they compare with the products of the action of the same reagents upon the so-called carbon-hydrates, gum, starch, &c., pointing out the close relationship between the two classes of derivatives. The substances selected for examination were caseine, albumen and fibrine, vegetable albumen and legumine. These substances were treated with bromine and water as long as the bromine appeared to exert an action, and the products of the action of bromine separated by processes for which we must refer to the original paper. The results finally reached showed that under the circumstances the products of the decomposition were—

Bromacetic acid,	Asparagic acid,	Leucine,	Tribromamido-benzoic acid.
Bromoform,	Malamic acid (?)	Leucimid,	
Carbonic acid,	Oxalic acid,	Capronic acid,	Bromanil,

together with some ammonia and humus-like substances. Tyrosin was not found in any case; but the authors suggest that it was converted by the action of bromine into bromanil. The products were qualitatively the same for all the substances examined, but quantitatively different, so that the authors infer that the members of the group do not contain a common base like the proteine of Mulder. The action of bromine upon the proteine bodies, like that of other agents of decomposition, yields two classes of products—those which belong to the fatty and those which belong to the aromatic group. Neither of these groups contains more than six atoms of carbon in the principal chain, so that they may be considered as derived respectively from the hydrocarbons, $Є_6H_{14}$ and $Є_6H_6$. Only the highest terms are characteristic of the proteine bodies, namely—leucine, asparagic acid, glutamic acid and tyrosin. All the others are merely derivatives of them.—*Ann. der Chemie und Pharmacie*, clix, p. 304. W. G.

3. *On the products of the reduction of silicic ether and some of its derivatives.*—LADENBURG has studied the action of zinc-ethyl and sodium upon silicic ether. The first product of the reduction is the silico-propionic ether of Friedel and Ladenburg, $SiЄ_2H_5(\Theta Є_2H_5)_3$. When this is repeatedly treated with zinc-ethyl and sodium, a second product is obtained which has the formula

$$Si(Є_2H_5)_2(\Theta Є_2H_5)_2.$$

The density of this liquid is 0·8752 at 0° C., and its boiling point 155°·5. The author terms it silicium diethyl-keton-ether. It is unchanged in the air, insoluble in water, soluble in alcohol and ether. By long boiling with caustic alkalies it is decomposed, and silico-propionic acid may be obtained from the solution. By treating with chloracetyl or chlorbenzoyl the ethyl groups are exchanged for chlorine, while acetic or benzoic ether is formed. Thus in the latter case we have—

$$Si(Є_2H_5)_2(\Theta Є_2H_5)_2 + 2Є_7H_5\Theta Cl = Si(Є_2H_5)_2Cl_2 + 2(Є_7H_5\Theta . \Theta Є_2H_5).$$

With one molecule of chloracetyl or chlorbenzoyl, the reaction is different; thus we have—

$$\mathrm{Si(Є_2H_5)_2(ΘЄ_2H_5)_2 + Є_2H_3ΘCl = Si(Є_2H_5)_2Cl(ΘЄ_2H_5)}.$$

Silicium-diethyl-chlorethin, $\mathrm{Si(Є_2H_5)_2Cl(ΘЄ_2H_5)}$, boils at 148° C.; silicium-diethyl chloride, $\mathrm{Si(Є_2H_5)_2Cl_2}$, at 129° C. Both are liquids which fume in the air, and burn with a green bordered flame, leaving silica. By the action of water upon the diethyl chloride the author obtained a viscid syrup, the analyses of which agreed tolerably with the formula, $\mathrm{Si(Є_2H_5)_2Θ}$. The author considers this substance identical with that obtained by Friedel and Crafts by the action of fuming nitric acid upon silicium-ethyl, and for which they proposed the same formula. By the further action of sodium and zinc-ethyl upon silicium-diethyl keton ether the author obtained an ether having the formula, $\mathrm{Si(Є_2H_5)_3(ΘЄ_2H_5)}$, which he terms silico-heptyl ether, boiling at 153° C. Iodhydric acid reacts with this body according to the equation:

$$\mathrm{2Si(Є_2H_5)_3(ΘЄ_2H_5) + 2IH = (Si(Є_2H_5)_3)_2Θ + 2Є_2H_5I + ΘH_2}.$$

Silicium triethyl oxide, $\mathrm{(Si(Є_2H_5)_3)_2Θ}$, was first obtained by Friedel and Crafts. The new reaction furnishes a method of obtaining it more easily. In conclusion, the author points out a certain regularity in the physical properties of the best known members of the silicium-ethyl series. We have—

		Boiling point.	Density at 0°.
Silicic ether,	$\mathrm{Si(Є_2H_5)_4Θ_4}$	166°·5	0·9676
Silico-prop. ether,	$\mathrm{Si(Є_2H_5)_4Θ_3}$	158°·5	0.9207
Silico-diethyl-keton,	$\mathrm{Si(Є_2H_5)_4Θ_2}$	155°·5	0·8752
Silico-heptyl ether,	$\mathrm{Si(Є_2H_5)_4Θ}$	153·	0·8414
Silicium-ethyl,	$\mathrm{Si(Є_2H_5)_4}$	152°·5	0·7657

—*Berichte der Deutschen Chem. Gesellschaft, Jahrgang* iv, 726. W. G.

II. Geology and Natural History.

1. *Triassic Sandstone of the Palisade Range.*—The Triassic (or Triassico-Jurassic) rock, in New Jersey, as well as Connecticut, is generally a distinct granitic sandstone, that is, it is largely made up of pulverized granite or gneiss. This rock in the Palisade range, New Jersey, is very fine-grained, and has been called *felsite* by Prof. Wurtz, and also by Dr. P. Schweitzer, in a paper on its composition in the American Chemist, July, 1871, p. 23. Five specimens were analyzed, and all were *granular*, and feldspar could be readily distinguished under the microscope. Mr. Schweitzer found the first four to contain ingredients corresponding to 30 to 60 per cent. of albite, showing that the granitic rock out of which these New Jersey fine-grained sandstones were made was albitic. The rock from the Newark quarries consists, according to him, of albite 50·46 per cent, quartz 45·49, soluble silica

0·30, water 1·14, bases dissolved out by hydrochloric acid 2·19=100·30. It would be of geological interest to find the locality of the albitic granitoid rocks that afforded the material for these sandstones (as we should call them, the term *felsite* being used not for a rock of a peculiar constitution, but rather for one of flint-like or impalpable texture). The Triassic sandstones of the vicinity of New Haven, Ct., contain orthoclase instead of albite, and the material is evidently from the rather coarse granites that lie just west of the sandstone. D.

2. *Martius, Flora Brasiliensis.*—Fascicles 51, 52, 53 and 54 have all appeared during this current year; the first bears the date of February, the last of July, 1871. The enlightened Emperor of Brazil, while in Germany this year (where he visited the grave of von Martius, and plucked and preserved some flowers as a *souvenir*) had the satisfaction of observing the rapid progress of this great national work, under Dr. Eichler's efficient direction. Dr. Eichler has this year been called to fill the chair of Botany at Gratz, with which is combined the directorship of the Botanic Garden. But he is able to carry on the Flora of Brazil, which will still be printed at Munich. With the fascicles now published, title-pages are issued for the volumes or parts of volumes (when the size of the volume calls for a division) already completed. It appears that eight volumes, or rather six half-volumes and two full volumes, are now ready for the binder.

Fascicle 51, by Doell of Baden, commences the *Gramineæ*, but includes only the small tribes of *Oryzeæ* and *Phalarideæ*, the later in the Kunthian rather than the Brownian sense. The *squamulæ* are maintained to be some of them perigonial, but others of stipular nature, i. e., stipules of paleæ. *Oryza* is made to include *Leersia* as a section. *Oryza sativa* and *O. monandra*, *Coix lachryma*, and *Zea Mays* are figured, as also a few rarer grasses.

Fasc. 52, besides Meissner's supplement to *Convolvulaceæ* (Geography and uses) contains the *Cuscutaceæ* by Dr. Progel and *Hydroleaceæ* and *Pedalineæ* by A. W. Bennett of London. Dr. Progel claims for these plants the rank of an order, on the ground of the structure of the embryo, the amount of albumen, and the simply imbricative æstivation of the corolla. Yet in the diagnostic character we read; "*corolla* .... *lobis* .... *per æstivationem contortis*." With good judgment, he refers all to the one genus *Cuscuta*, and gives a conspectus of all the tropical and subtropical American species, after Engelmann. Eighteen Brazilian species are described, one figured at large, and the flowers, seeds, &c., of all of them after the manner of Engelmann's original monograph, which led the way to the present understanding of the genus, and whose more recent and elaborate "systematic arrangement" is almost implicitly followed.

The *Hydroleaceæ* are equally maintained by Mr. Bennett as an independent order, a matter which may almost equally well be decided either way; but we have before alluded to a connecting link between this group and the *Hydrophyleaceæ* which our author

overlooks. Five species of *Hydrolea* and one of *Wigandia* are all that are claimed for the Brazilian flora. The *Pedalineæ* count two genera of a single species each and one of three species.

The 53d fasciculus contains the *Irideæ*, elaborated by Dr. Klatt of Hamburg, and illustrated by 8 plates. It is stated that the known species of the order amount to 470, of which 251 are African, 109 American, 50 Asiatic, 42 European, and 13 Australian. The Brazilian flora counts 57; but there is no *Iris* among them, nothing nearer than a solitary *Cipura.* Nuttall's genus *Nemastylis* has a south Brazilian representative. *Tigridia Pavonia* would appear to inhabit Brazil as well as Mexico, and S. America is the home of *Sisyrinchium*, of which 21 species are Brazilian.

Fasc. 54 comprises the *Escallonieæ* and *Cunoniaceæ*, by Dr. Engler of Breslau, and the *Connaraceæ* and *Ampelideæ* by Mr. Baker of Kew. *Escallonia* counts up to 43 species in Brazil, and *Weinmannia* almost as many. The 35 Brazilian species of *Connaraceæ* are divided among four genera; and there are good figures, with full details, filling seven plates. Of *Ampelideæ* there are 35 species of *Vitis* (taken in the largest sense); and five plates are given. The remaining orders of *Polypetalæ* will soon be forthcoming, and then the *Euphorbiaceæ.* A. G.

3. *Baillon's Histoire des Plants*, in a series of monographs, is making progress, notwithstanding all untoward events. We have before us the monograph on *Menispermaceæ* and *Berberidaceæ*, illustrated by 73 admirable wood-engravings; and that on *Nymphæaceæ*, with 34 figures, both issued in 1871. The illustrations of the *Cocculus* series are taken from *Anamirta Cocculus* (the officinal Cocculus Indicus), our own *Cocculus Carolinus*, and the *Menispermum Dahuricum*, which is very like our own species. The *Cissampelos* series has capital illustrations of the officinal *Cissampelos Pareira.* The *Chasmanthera* series, to which our *Calycocarpum* belongs, is illustrated by *Chasmanthera Columba*, which furnishes the Columbo of Madagascar.

Baillon follows Bentham and Hooker in referring the *Lardizabaleæ*, as a tribe, to the *Berberidaceæ.* But his great point is that he finds in *Erythrospermum* of Lamarck, hitherto placed in the *Bixaceæ*, another syncarpous Berberideous genus, nearly related to the Chilian *Berberidopsis* of Hooker, and with it constituting a new tribe. The name *Bongardia* he replaces by *Chrysogonum* of Rauwolf and Bauhin (which would thus throw out Linnæus's own genus *Chrysogonum*); this going back beyond Tournefort would work endless trouble, if accepted; and by the same rule *Leontice* also should have given place to *Leontopetalum.* *Caulophyllum* is naturally considered as a section of *Leontice*, and all the genera separated from *Epimedium* are suppressed. Baillon has not mentioned the fact announced in this Journal, that *Podophyllum* occasionally exhibits more than one carpel, and he signifies a doubt whether the pulpy investment of the seeds is an arillus. This, however, the fresh fruit makes clear.

The *Nymphœaceæ* are taken in the most enlarged sense, and even are made to include the *Sarraceniaceæ*, which is surely widely beyond the mark. *Nelumbo*, *Cabomba*, *Nuphar*, *Nymphæa*, and *Euryale* are well illustrated; the latter genus is made to include *Victoria;* the quasi-monocotyledonous stems are described, &c. In the first instance the ovules of the *Cabombeæ* are said to be inserted in the internal angle of the ovaries (ventral suture); elsewhere they are more correctly said to be borne on the parieties of the cell; but it is nowhere mentioned that they are more commonly on or near the dorsal suture, and very rarely indeed upon the ventral, as Salisbury and then Brown long ago pointed out.

We should add that this important work, as fast as it appears, is translated into English and published in London, under the name of *A Natural History of Plants.* Reeve and Co. are the publishers. They issue it in monthly numbers, and the first volume is already issued, at 25 shillings; it has 503 wood-engravings.

A. G.

4. *Baptisia perfoliata ; the arrangement and morphology of its Leaves.*—In a paper sent by Mr. Ravenel to Prof. Gray, and read by him at the last meeting of the American Association for the Advancement of Science, the character of the torsion of the stem by which the foliage on summer shoots becomes unilateral, is explained. It had been hastily supposed by the present writer that the leaves were five-ranked, and became one-ranked by a continuous torsion of the stem. Mr. Ravenel points out that the phyllotaxis of the plant in question is really of the two-ranked order, which inspection of the growing shoots makes abundantly clear, and that they become one-ranked by the alternate twisting of the successive internodes right and left, i. e., one twists to the right, the next as much to the left, the next in the opposite direction, and so on, thus bringing the leaves into a vertical position all on one side of the horizontal branch. It occurred to Mr. Ravenel that this vertical position of the leaves was correlated with the remarkable alternate torsion of the axis, namely, that the leaves on the reclining branches were adjusting themselves so as to present their two faces as equally as possible to the light, as is done by those of the Compass plant in a different way; and that it was therefore probable that the stomata would be found to be as numerous on the upper face of the leaf as on the lower. A microscopical examination proved the correctness of Mr. Ravenel's conjecture; the stomata are about equally numerous on the two faces. Whether the leaves take a vertical position because the stomata occupy both surfaces, or whether the stomata are so distributed because the leaves stand edgewise to the zenith, is a question. The fact is that the two are thus correlated, and such correlation is ordinarily essential to the well-being of the plant. It may be remarked, however, that the stomata do not manifestly appear until the leaf is pretty well developed. Also that this distribution of the stomata is peculiar to the species in question. At least the leaves of *B. australis* and *B. leucantha*, which retain

their horizontal position, are provided with stomata only on their lower face. The question next arises whether *B. perfoliata* really differs in its normal phyllotaxis from its congener. We find that it does not, that in *B. australis*, *leucantha* and *alba*, and in *B. perfoliata* likewise (these being all the species at present cultivated in the Cambridge Botanic Garden), the arrangement of the leaves at the base of the main stem is of the tristichous order, but that after the first or second cycle, especially on the branches, this changes to the distichous order. The difference between *B. perfoliata* and its congeners, therefore, is not in the normal arrangement of the leaves, but in the fusion of the axis and the distribution of the stomata, adopting the foliage to its vertical position.

The form of the leaves in *Baptisia perfoliata* is remarkably peculiar. Most of the species have trifoliate leaves and a pair of stipules; this has to all appearance a simple and entire perfoliate leaf and no stipules. It is, however, a natural supposition that the apparently simple leaf consists either of a pair of stipules, or of such stipules and a leaflet, connate into a rounded disk. This supposition Mr. Ravenel has just now had the good fortune to verify, by finding some abnormal shorts of *B. perfoliata*, one of which is in our possession. Most of its leaves are cordate-clasping rather than perfoliate, and with or without a retuse or emarginate apex; some almost two-parted so as to represent pretty obviously a pair of stipules; and one of like conformation but with an obvious terminal leaflet in the sinus! Mr. Ravenel remarks that this is a manifest step toward his own *B. stipulacea*. But it hardly invalidates that species, although the inflorescence and legume of the two are quite alike. A. G.

5. *Drosera* (*Sundew*) *as a Fly-Catcher.*—A valued correspondent and accurate observer, Mrs. Treat of Vineland, New Jersey, writes:

"For several summers in succession I have taken *Drosera rotundifolia*, *D. longifolia* and *D. filifolia* from their moist beds, and placed them in sand and water in such a way that they made most charming window-plants. What I take for *D. longifolia* has spatulate-oblong reddish leaves, and long, erect, reddish petioles covered with glands, like those of the leaf. This species I find a much more effective fly-trap than *D. rotundifolia*. On some of the plants in my window this summer almost every leaf held a common house-fly prisoner until it died, and it did not take the leaf very long to fold completely round its victim. My husband was terribly shocked, and thought it the most cruel thing he ever saw in nature; but with my prepossessions and habits, both as an entomologist and a house-keeper, I was contentedly interested to see the work go on."

If we rightly remember, in *D. rotundifolia* it is only the gland-tipped bristles that bend inward and hold the insect fast, while they probably suck the juice out of him. This folding of the blade of the leaf itself around the fly is a new fact to us, and is so especially interesting, being a step toward *Dionæa*, that we

would call particular attention to it, in the hope of further observations and independent confirmation. We are told that the blade incurves from apex to base, in the manner of its vernation. What was long ago known of the action of *Drosera rotundifolia* in fly-catching, had almost completely died out of the books and out of the memory of the present generation until very lately, and the most remarkable things relating to it and to *Dionæa* are not yet in print. A. G.

6. *Borodin: Changes in position of grains of Chlorophyll under Sunlight.*—The singular and prompt change in the position of the chlorophyll grains, discovered by Famintzin and verified by Borodin in Mosses, has been found by the latter to occur in the higher Cryptogamia as well, and now also in Phanerogamous plants, both aquatic and terrestrial. The paper in Bull. Acad. St. Petersb. vol. 13, 1869, is reproduced in the Ann. Sci. Nat., ser. 5, t. 12. *Lemna*, *Ceratophyllum* and *Callitriche* are among the aquatic plants in which the phenomenon has been observed, and *Stellaria media* among terrestrial. *Lemna trisulca* is one of the best plants for these observations. Under diffuse day-light the grains of chlorophyll are distributed over the cell-walls parallel to the surface of the leaf or frond. Under the direct light of the sun they are rapidly (within 15 minutes or less) transported to the lateral walls. There they are at first uniformly distributed. But upon longer insolation, say for three-quarters of an hour, they became grouped in clusters. In darkness the chlorophyll is likewise upon the lateral walls. Thus absence of light produces essentially the same effect as direct sunshine, but less strikingly. Whether these changes are passive and caused by movements of the colorless protoplasm, as Sachs supposes, or active, is not made out. But the movements, according to Borodin, are in response only to the more refrangible rays. A. G.

7. *Dehérain: Evaporation of Water and decomposition of Carbonic acid by foliage.*—Some notice of Dehérain's papers, read before the Academy of Science, Paris, in August and October, 1869, have already been referred to in this Journal. A full abstract published last summer in the Am. Sci. Nat. (ser. 5, tome 12) has come to hand. One of the first and least expected results, which came to light early in the investigation, and simplified the experiments considerably, was:—

(1.) That the transpiration of water continued indefinitely, and quite constantly, in a saturated atmosphere.

(2.) This evaporation, copious in light and almost null in darkness, is determined by the light, and not by the heat of the sun.

(3.) It is much greater from young leaves than from older ones.

(4.) And is mainly caused by the luminous rays (yellow and red).

(5.) The difference in this respect is manifest even when the less refrangible and more refrangible rays are brought to an equal luminous intensity.

(6.) The evaporation of water is much more copious from the *upper* than from the lower face of the leaf. This result, in view

of the structure of the leaf, and the situation of the stomata, is most unexpected.

(7.) Since the decomposition of carbonic acid also takes effect under the yellow and red rays mainly, and in the upper rather than the lower face of the leaf, the relation between these two capital functions of foliage appears to be intimate and is certainly noteworthy. A. G.

8. *Herbarium.*—The Herbarium of a veteran European Botanist, one of much importance, is offered for sale, the proprietor wishing to see to its satisfactory disposition during his life-time, if possible. Particulars may be obtained from the writer of this notice upon enquiry addressed to the editors of this Journal.

A. G.

III. Astronomy.

1. *Note on the Spectrum of the Aurora;* by Geo. F. Barker.—On the evening of November 9th, there appeared one of the most magnificent crimson auroras ever seen at this place. When first observed, at about a quarter before six, P. M., it consisted of a brilliant streamer shooting up from the northwestern horizon; this was continued in a brilliant red, but rather nebulous mass of light, passing upward and to the north. Its highest points were from 30° to 40° in altitude. A white aurora, consisting of bright streamers, appeared simultaneously, and extended round to the northeast.*

The crimson aurora was examined with the spectroscope at six o'clock. The instrument used was a single glass-prism spectroscope, made by Duboscq of Paris. On directing the slit toward the brilliant streamer above mentioned, a bright spectrum was observed, consisting of five well-marked lines. A millimeter scale attached to the instrument was then illuminated with a gas-flame, the auroral lines being readily measured, even when the numbers on the scale were bright enough to be read distinctly. The sodium line was used to adjust the scale, being equally divided by the division 100; the width of the slit was about one millimeter. As thus arranged, the five auroral lines, beginning at the red end, had the following positions: Scale-Nos. 90, 110·5, 130, 138, 149. The brightness of the lines was, following the above order, 3, 1, 5, 2, 4, the second line from the red end of the spectrum being the brightest. The line marked 90 and the one marked 110·5 were sharp and well-defined; the others were all nebulous on the edges. Before the measurements were completely verified by a second comparison, the crimson aurora entirely vanished, having endured less than a half hour. In the white aurora which remained, the spectroscope showed four of the five lines given; the crimson line

* Professor Newton informs me that he observed an equally brilliant red patch of auroral light in the northeast, five or ten minutes earlier. Since the lower end of the red streamers was much lower than that of the white, it would seem as if the red were seen through the white, the red being most remote.

alone was absent. The measurements are exact to half a division of the scale.

To determine the approximate wave-lengths of these lines comparison was made both with certain elemental lines and with the lines of the solar spectrum. On the scale of this instrument, the elemental lines employed read as follows:—

Kα 63, Liα 79, Srβ 80, H(*c*) 82, Caα 91, Srα 96, Caβ 113, H(*f*) 146·5, Srδ 163, Csβ 165, Csα 167, Rbα & β 200, Kβ 218.

The Fraunhofer lines measured as follows:—

a 70·5, B 76, C 82, D 100, E 124·5, *b* 130, F 146·5, G 189.

Direct interpolation was used in comparing the wave-lengths of the auroral lines with those given above, the wave-lengths of the Fraunhofer and elemental lines being taken from Gibbs's tables (this Journal, II, xliii, 1; xlvii, 194). This method was believed capable of giving results as close as the instrumental measurements. In this way the wave-lengths of the five auroral lines were obtained as given in the following table:—

Line.	Scale number.	Wave-length.	Auroral lines.	Other measurements.
B	76	687		
C	82	656		
(1)	90	623	623	627 Zöllner.
D	100	589		
(2)	110·5	562	562	557 Angström.
E	124·5	527		
(3)	130	517	517	520 Winlock.
b	130	517		
(4)	138	502	502	
F	146·5	486		
(5)	149	482	482	485 Alvan Clark, Jr.
G	189	431		

In this table, column 1 gives the auroral and the Fraunhofer lines; column 2, the number of these as measured upon the scale of the spectroscope used; column 3, the wave-lengths of these lines obtained as above stated; column 4, the wave-lengths of the auroral lines, given by themselves; and column 5, the wave-lengths of what I assume to be the same lines, with their wave-lengths as measured by the observers mentioned.

The point of particular interest in this observation is the fact that the line (4) of wave-length 502 is not laid down in any authority accessible to me as having been observed in the auroral spectrum. Indeed, no previous observer, so far as I know, has seen any auroral line between the Fraunhofer lines *b* and F. Professor C. A. Young (this Journal, III, ii, 332, Nov., 1871) gives two lines —Nos. 56 and 57, or 1866·8 and 1870·3 of Kirchhoff—observed by him in the sun's chromosphere and also by Rayet in the eclipse of 1868, one of which may coincide with this fourth auroral line.

New Haven, Nov. 13, 1871.

[NOTE.—Since the above was in type, the *Astronomische Nachrichten* for October 24th, No. 1864, has been received. It contains a notice of auroral spectra as observed at the Bothkamp Observatory by H. Vogel, which is dated August, 1871. In ordinary auroras 6 lines were seen, in the red streamers 7. The following are the wave-lengths given:—

629·7	Very bright line.
556·9	Brightest line of the spectrum. Markedly weaker when the red line is also present.
538·2	Very faint line. (Doubtful.)
523·3	Pretty bright line.
518·9	Very bright when the red line is present. At other times, as bright as the last.
500·3	Pretty bright line.
from 469·4 to 462·9	Broad band, brighter in the center. Very weak in the red streamers.

The line of wave-length 500·3 is apparently the same observed by me, and given as 502.

Vogel thinks he has obtained evidence in support of the assumption that the auroral spectrum is an air spectrum, modified by conditions of pressure and temperature.

The whole number of lines which have been seen and measured in the spectrum of the aurora by different observers appears to be 11, as follows:—

No.	Description.	Wave-length.	Observer.
1.	Bright red line	640, 630	H. R. Procter.
		629·7	Vogel.
		627·9	Zöllner.
		623	Barker.
2.	Brightest line in the spectrum	562	Barker.
		557	Winlock.
		556·9	Vogel.
		556·7	Angström.
3.	Band	544	Winlock.
4.	Very faint line	538·2	Vogel.
5.	Band (coronal line ?)	532	Alvan Clark, Jr.
		531	Winlock.
6.	Pretty bright line	523·3	Vogel.
		520	Winlock.
7.	Bright line (*b* ?)	518·9	Vogel.
		517	Barker.
8.	Pretty bright line	502	Barker.
		500·3	Vogel.
9.	Band (F ?)	485	Alvan Clark, Jr.
		482	Barker.
10.	Band	462·9 to 469·4	Vogel.
		464	Winlock.
11.	Band (G ?)	434	Alvan Clark, Jr.

Many other observations of auroral spectra have been made, but in most cases the lines were not measured even approximately.

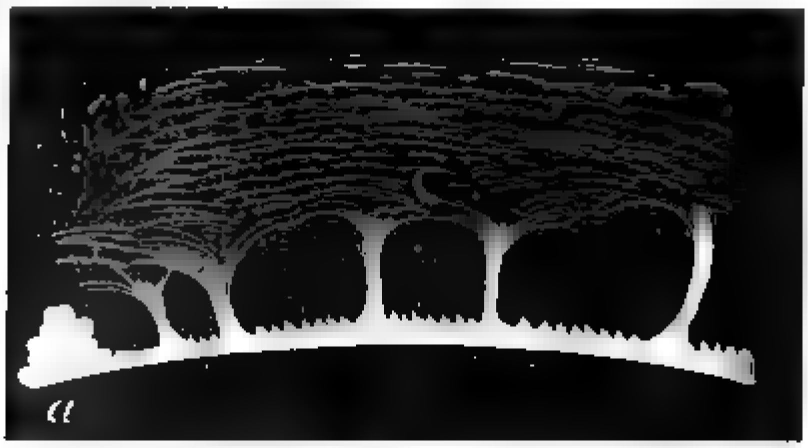
G. F. B.]

2. *An Explosion on the Sun;* by C. A. Young. (Boston Journal of Chemistry).—On the 7th of September, between half past twelve and two P. M., there occurred an outburst of solar energy remarkable for its suddenness and violence. Just at noon the writer had been examining with the telespectroscope* an enormous protuberance of hydrogen cloud on the eastern limb of the sun.

It had remained with very little change since the preceding noon—a long, low, quiet-looking cloud, not very dense or brilliant, nor in any way remarkable except for its size. It was made up mostly of filaments nearly horizontal, and floated above the chromosphere† with its lower surface at a height of some 15,000 miles, but was connected to it, as is usually the case, by three or four vertical columns brighter and more active than the rest. Lockyer compares such masses to a banyan grove. In length it measured 3′ 45″, and in elevation about 2′ to its upper surface—that is, since at the sun's distance 1″ equals 450 miles nearly, it was about 100,000 miles long by 54,000 high.

At $12^h\ 30^m$, when I was called away for a few minutes, there was no indication of what was about to happen, except that one of the connecting stems at the southern extremity of the cloud had grown considerably brighter, and was curiously bent to one side; and near the base of another at the northern end a little brilliant lump had developed itself, shaped much like a summer thunderhead. Figure 1 represents the prominence at this time, *a* being the little "thunder-head."‡

1.



What was my surprise, then, on returning in less than half an hour (at $12^h\ 55^m$), to find that in the meantime the whole thing had been literally blown to shreds by some inconceivable up-rush from

* This is the name given by Schellen to the combination of astronomical telescope and spectroscope.

† The *chromosphere* (called also *sierra* by Proctor and others) is the layer of hydrogen and other gases which surrounds the sun to a depth of about 7,000 miles. Of this the prominences are mere extensions.

‡ The sketches do not pretend to accuracy of detail, except the 4th; the three *rolls* in that are nearly exact.

beneath. In place of the quiet cloud I had left, the air, if I may use the expression, was filled with flying débris—a mass of detached vertical fusiform filaments, each from 10″ to 30″ long by 2″ or 3″ wide, brighter and closer together where the pillars had formerly stood, and rapidly ascending.

When I first looked some of them had already reached a height of nearly 4′ (100,000 miles), and while I watched them they rose with a motion almost perceptible to the eye, until in ten minutes ($1^h\ 05^m$) the uppermost were more than 200,000 miles above the solar surface. This was ascertained by careful measurement; the mean of three closely accordant determinations gave 7′ 49″ as the extreme altitude attained, and I am particular in the statement because, so far as I know, chromospheric matter (*red-hydrogen* in this case) has never before been observed at an altitude exceeding 5′. The velocity of ascent also, 166 miles per second, is considerably greater than anything hitherto recorded. A general idea of its appearance, when the filaments attained their greatest elevation, may be obtained from figure 2.

As the filaments rose they gradually faded away like a dissolving cloud, and at $1^h\ 15^m$ only a few filmy wisps, with some brighter streamers low down near the chromosphere, remained to mark the place.

2.

But in the meanwhile the little "thunder-head," before alluded to, had grown and developed wonderfully into a mass of rolling and ever-changing flame, to speak according to appearances. First it was crowded down, as it were, along the solar surface; later it rose almost pyramidally 50,000 miles in height; then its summit was drawn out into long filaments and threads which were most curiously rolled backward and downward, like the volutes of an Ionic capital; and finally it faded away, and by $2^h\ 30^m$ had vanished like the other. Figures 3 and 4 show it in its full development; the former having been sketched at $1^h\ 40^m$, and the latter at $1^h\ 55^m$.

The whole phenomenon suggested most forcibly the idea of an *explosion* under the great prominence, acting mainly upward, but also in all directions outward, and then after an interval followed by a corresponding in-rush: and it seems far from impossible

that the mysterious coronal streamers, if they turn out to be truly solar, as now seems likely, may find their origin and explanation in such events.

3.

4.

The same afternoon a portion of the chromosphere on the opposite (western) limb of the sun was for several hours in a state of unusual brilliance and excitement, and showed in the spectrum more than 120 bright lines whose position was determined and catalogued,—all that I had ever seen before, and some 15 or 20 besides.

Whether the fine aurora borealis which succeeded in the evening was really the earth's response to this magnificent outburst of the sun is perhaps uncertain, but the coincidence is at least suggestive, and may easily become something more if, as I somewhat confidently expect to learn, the Greenwich magnetic record indicates a disturbance precisely simultaneous with the solar explosion.

Dartmouth College, September, 1871.

3. *November Meteors in* 1871.—On the night of November 13th–14th, the writer, with Prof. Lyman and about two others, watched for meteors from $11^h\ 20^m$ onward, with the following results:—

Between	$11^h\ 20^m$	and	$11^h\ 30^m$	we saw	9	meteors.	Sky $\frac{4}{5}$ obscured.
"	30	"	45	"	8	"	Fewer clouds, [but hazy.
"	45	"	12 0	"	3	"	
"	12 0	"	15	"	8	"	
"	15	"	30	"	17	"	Nearly clear.
"	30	"	45	"	13	"	
"	45	"	1 0	"	15	"	
"	1 0	"	15	"	14	"	Sky $\frac{1}{5}$ overcast.
"	15	"	30	"	5	"	
"	30	"	45	"	6	"	Sky $\frac{9}{10}$ overcast.

Shortly after $1^h\ 45^m$ the clouds had entirely closed over, and did not break away afterward. A very few of the 98 meteors seen were of the November meteor system, not more, we judged, than $\frac{1}{10}$ of the number seen. We were therefore at the time of the watch not in the meteor stream. If the earth passed through it this year, it did so earlier than $11^h\ 20^m$, or later than $1^h\ 20^m$, of the night of the 13th–14th. H. A. N.

4. *Asteroid* (117).—This new planet was discovered by Borelly at Marseilles two days before it was seen by Luther. It has received the name *Lomia.*

5. *Tuttle's Comet.*—This comet, first discovered by Méchain in 1790, and again by Tuttle in 1858, and which has a period of 13·6 years, was again seen at Marseilles October 15th, and at Karlsruhe October 15th.

IV. Miscellaneous Scientific Intelligence.

1. *Plattner's Manual of Qualitative and Quantitative Analysis with the Blowpipe*, from the last German edition, revised and enlarged by Professor Theodore Richter, of the Royal Saxon Mining Academy. Translated by Henry B. Cornwall, A.M., E.M., Assistant in the Columbia College School of Mines, New York, assisted by John H. Cadwell, A.M. With 87 wood-cuts and 1 lithographic plate. xv and 549 pp. 8vo. New York, 1872. (D. Van Nostrand, 23 Murray St.).—Plattner's celebrated work has long been recognized as the only complete book on blowpipe analysis. The fourth German edition, edited by Prof. Richter, fully sustains the reputation the earlier editions acquired during the lifetime of the author, and it is a source of great satisfaction to us to know that Prof. Richter has coöperated with the translator in issuing the American edition of the work, which is in fact a fifth edition of the original work, being far more complete than the last German edition.

The American editor, Mr. Cornwall, has done a very great service for all students of chemistry and mineralogy who use the English tongue, in thus adding to our scientific literature a work of such rare merit. He has showed excellent judgment in rendering the work into good English, in avoiding needless repetitions, in adding a large amount of valuable material, and in adopting a mineralogical nomenclature which is familiar to American scientific men.

2. *Geological exploration under* Dr. Hayden.—The geological expedition to the Rocky Mountain region under the charge of Dr. Hayden, after completing the survey of the Yellow Stone Valley, left Fort Ellis on the 5th of September, passing down Gallatin Valley to the Three Forks, and thence by the Jefferson to its very source, exploring many of its branches, and pursuing a direction nearly parallel to that which the party had traversed in the June previous.

The valleys of the Gallatin, Madison and Jefferson forks of the Missouri, with all the little branches, were found occupied by industrious farmers and miners—a contrast quite striking to the doctor, who, twelve years ago, in exploring that same region, met with not a single white inhabitant.

The Rocky Mountain Divide was crossed at the head of Horse

Plain Creek, from which the party passed over into Medicine Lodge Creek, following this down into the Snake River Plain. An interesting fact observed was the occurrence of two species of trout in great quantity in streams such as Medicine Lodge, Comas, and other creeks, all sinking into the plains after a course of from fifty to seventy-five miles. The trout appeared to be of the same two species in all, although the waters had no apparent connection. —X., *in Harper's Weekly.*

3. *Madagascar.*—Few geographical researches of modern times have been more interesting than those carried on in Madagascar by M. A. Grandidier, whether we consider our previous ignorance of the region in question or the number of striking and important scientific novelties brought to light. We have already referred to the return of this gentleman from his third expedition, the first having been commenced in 1865. On this occasion he attempted to reach the heart of the island, but in vain; and in the following year he explored the southern region, but did not reach the mountains. In 1869–70, however, he traversed the entire breadth of the island three times, from west to east, through its whole extent, making various lateral excursions to interesting points, and visiting the peak of the mountain Ankaararatre, the highest summit in Madagascar. According to the report just presented by M. Grandidier to the Academy of Sciences of Paris, Madagascar comprises two distinct regions—the northern, which is mountainous, and that to the south and east, which is flat. He ascertained that there are five chains of mountains, which have generally the same direction —namely, from northeast to southwest. These are separated by sandy and arid plains, intersected by shallow ravines. After crossing the fourth chain, a region is reached of which the general level is from 1000 to 1200 meters in height, extending to the Indian Ocean, a vast sea of mountains, with no level lands except a few small valleys used for the cultivation of rice.

The eastern coast is intersected at almost every step with rivers and torrents; and the northwestern provinces pour into the sea a large number of important rivers. On the southern and western regions, however, the case is quite different, there being distances of fifty leagues without the smallest brook. The reputation possessed by Madagascar for luxuriant vegetation and fertile soil, according to M. Grandidier, is by no means merited, its provinces being neither rich nor productive. The secondary plains are sterile, and the population is confined to the immediate banks of the water-courses. The entire mass of the granitic mountains, situated to the west of the eastern slope, is naked and arid, and there is no vegetation excepting here and there little bunches, growing in the ravines. In the opposite direction, however, there is some degree of fertility; and there is a line of forests extending from north to south, which connect with those of the west, forming around the island a narrow girdle, including a dry and desert region in its center.

M. Grandidier made numerous astronomical, meteorological, and magnetical observations. He also studied closely the ethnology of the inhabitants, having taken a great many measurements upon the living body, and having collected notes of the habits, language, and traditions of the people. His natural history collections embrace over fifty new species of vertebrates, together with numerous insects and plants. Large numbers of alcoholic specimens were also gathered, for the purpose of further investigation into the anatomy and structure of the entire animal.—X., *in Harper's Weekly.*

4. *Dr. A. Habel.*—After a seven years' tour of exploration in South America, Dr. A. Habel, a former resident of Hastings-on-the-Hudson, has returned to New York, where he is assiduously engaged in preparing the results of his labors for the press. Among the regions traversed by this gentleman may be mentioned the greater part of Central America, the Cordilleras of the Andes in Colombia, Ecuador, and Peru, and finally the Chincha Islands and the Galapagos. During this whole period Dr. Habel was diligently occupied in gathering information in regard to the natural and physical history of the countries mentioned, especially in the departments of ethnology, meteorology, and zoology. He has already made some communications on the subject of his travels to the Academy of Sciences at Paris, and other learned bodies, and we look forward to his detailed report with anticipations of much interest. The guano deposits of Chinchas were thoroughly explored by the doctor, who found them to be of a much more complicated structure than has hitherto been supposed.—X., *in Harper's Weekly.*

5. *On Sea Waves;* by W. J. Macquorn Rankine, C.E., LL.D., F.R.S. (Royal Institution of Great Britain, May 26, 1871.)—The speaker in the first place gave a summary, illustrated by diagrams and machines, of the existing knowledge of the mode of motion of water in waves, and of the geometrical and dynamical laws which govern the relations between the depth of disturbance of the water, the velocity of advance of waves, their periodic time, and their length. He referred to the experimental and theoretical researches of previous authors on the subject, such as Webers, Airy, Scott Russell, Caligny, etc.

He then explained the principle, of which Mr. Froude was the first to point out the importance, that the action of water agitated by waves upon a ship tends to make her perform the motions which would have been performed in her absence by the mass of water that she displaces. In still water, the forces of gravity and of buoyancy tend to keep the ship upright, and if she has been heeled over, to restore her to the upright position, and that tendency constituted the *statical stability* or *stiffness* of the ship. Among waves, the same forces, combined with the reactions due to the heaving motions of the water and of the ship, tend to place her in the position called *upright to the wave surface;* that is, with her originally vertical axis normal to the wave surface. If the ship

yielded passively to that tendency, like a broad and shallow raft, she would accompany the waves in their rolling; and thus, a ship having great *stiffness* may be very deficient in *steadiness*. Every ship has, like a pendulum, a natural period of rolling, depending on her stiffness, or tendency to right herself, and her moment of inertia, being a quantity depending on the distribution of her mass. Stiffness tends to shorten, and inertia to lengthen, the period. It was shown in 1862, by Mr. Froude, that the greatest unsteadiness and the greatest danger of being overturned takes place when the periodic times of rolling of the ship and of the waves are equal; for then each successive wave adds to the extent of roll; and if the coincidence of the periods were exact, the ship would inevitably be overturned in the end.

In the course of the present spring it has been pointed out that in well-designed ships a safeguard exists against the occurrence of such disasters. It is well known that no pendulum is absolutely isochronous; but great oscillations occupy a longer time than small oscillations. In like manner, no ship is absolutely isochronous in her natural rolling; but great angles of roll occupy longer periods than small.* Hence, supposing a ship to encounter waves of a period equal or nearly equal to her own natural period for small angles of roll, her angle of rolling is at first progressively increased; but at the same time her natural periodic time of rolling is increased, until it is no longer equal or nearly equal to the periodic time of the waves; and thus she in a manner *eludes* the danger arising from coincidence of periods. In order, however, that this safeguard may act efficiently, it is essential that the natural period of the ship for the smallest angles of roll should not be less than the period of the waves; otherwise the first effect of the progressive increase of angle will be, not to destroy, but to produce coincidence of period; and the result will be great unsteadiness of motion, and possibly great danger.

The speaker described the above principles as being the latest additions to our knowledge of the theory of the relations between ships and sea-waves; and he illustrated them by means of experiments on a machine so constructed as to imitate the dynamical condition of a ship rolling among waves.

6. *On a Meteor seen at Alexandria, Egypt;* by BEVERLY KENNON, Colonel Coast Defense, Egyptian Army. (From a letter dated Alexandria, Egypt, Sept. 9th, 1871, addressed to Rear Admiral Sands, U. S. N., and by him communicated for this Jour-

* An exception to this rule exists in the case of that form of ship known as the "Symondite," in which the sides flare out at and near the water-line, so as to make the stiffness increase faster than the angle of heel. In such ships the period of rolling *shortens* when the angle increases; and thus the well-known unsteadiness of large vessels of that model is accounted for. In a small boat, whose natural periodic time for the smallest angle of roll is shorter than that of any of the waves which she encounters, the Symondite model does not promote unsteadiness; for the shortening of the natural period of rolling removes it farther from coincidence with the period of the waves.

nal.)—The meteor attracted my attention last night (Sept. 8th) and also that of my companions, and many other persons who were in the café on the sea-shore with me when it passed us in its flight. It was very large and bright, and starting from the zenith moved nearly due north, and exploded or disappeared when about 20° above the horizon, and about S.E. from the North Star. It moved leisurely and disappeared apparently behind a cloud; when watching for its reappearance, we were astonished to find that the luminous streak which marked its passage appeared to remain stationary from the point at which the meteor disappeared. As it maintained its brilliancy for some seconds, I noted the time by watch; it was then $11^h\ 14^m\ 30^s$ P. M. M. A. time. For one minute and ten seconds this brilliant streak, stretching toward the northern sky, and subtending an angle of about six degrees, remained perfectly straight and very bright; at the expiration of another minute it had changed its shape into that of a curve, convex toward the earth; at the end of two minutes and thirty seconds it was obtuse-angled, and of moderate brilliancy; at the end of the third minute it was right-angled in shape, and of a distinctness sufficiently great to attract attention, disappearing entirely after three minutes and twenty seconds from the time we first noticed it.

7. *Kansas Academy of Sciences.*—The Kansas Natural History Society, of Leavenworth, Kansas, changed its name to that of the Kansas Academy of Sciences, at its fourth annual meeting on the 25th and 26th of October. The officers of the Academy are Gen. John Fraser, President; B. F. Mudge and Robert J. Brown, Vice Presidents; John D. Parker, Secretary; F. H. Snow, Treasurer; B. F. Mudge and F. H. Snow, Curators. Several papers were read at the meeting on the Natural History and Geology of Kansas and on other topics.

8. *The Fossil Plants of the Devonian and Upper Silurian of Canada*, by J. W. DAWSON, LL.D., F.R.S., F.G.S. Geological Survey of Canada, Alfred R. C. Selwyn, F.G.S., Director. 100 pp., with 20 plates. Montreal, 1871. (Dawson Bros).—Dr. Dawson has here brought together the results of his long labors on the fossil Paleozoic botany of Canada, and made a volume of great value to Geology and to science in general. Its twenty plates are crowded with excellent figures. The closing chapter, forming a "supplementary section" to the volume, is republished on page 410 of this number. The memoir is worthy to take its place along side of the other Paleontological publications of the Canada Geological Survey.

Bulletin of the Wisconsin Academy of Sciences, Arts and Letters, Nos. 4 and 5, for Feb. and July. pp. 48 to 81. Madison, Wis.

INDEX* TO VOLUME II.

* The Index contains the general heads, Botany, Geology, Mineralogy, Zoology, and under each the titles of Articles referring thereto are collected.

* Omitted in Index of Vol. I:
Marsh, new fossil serpents, 447.